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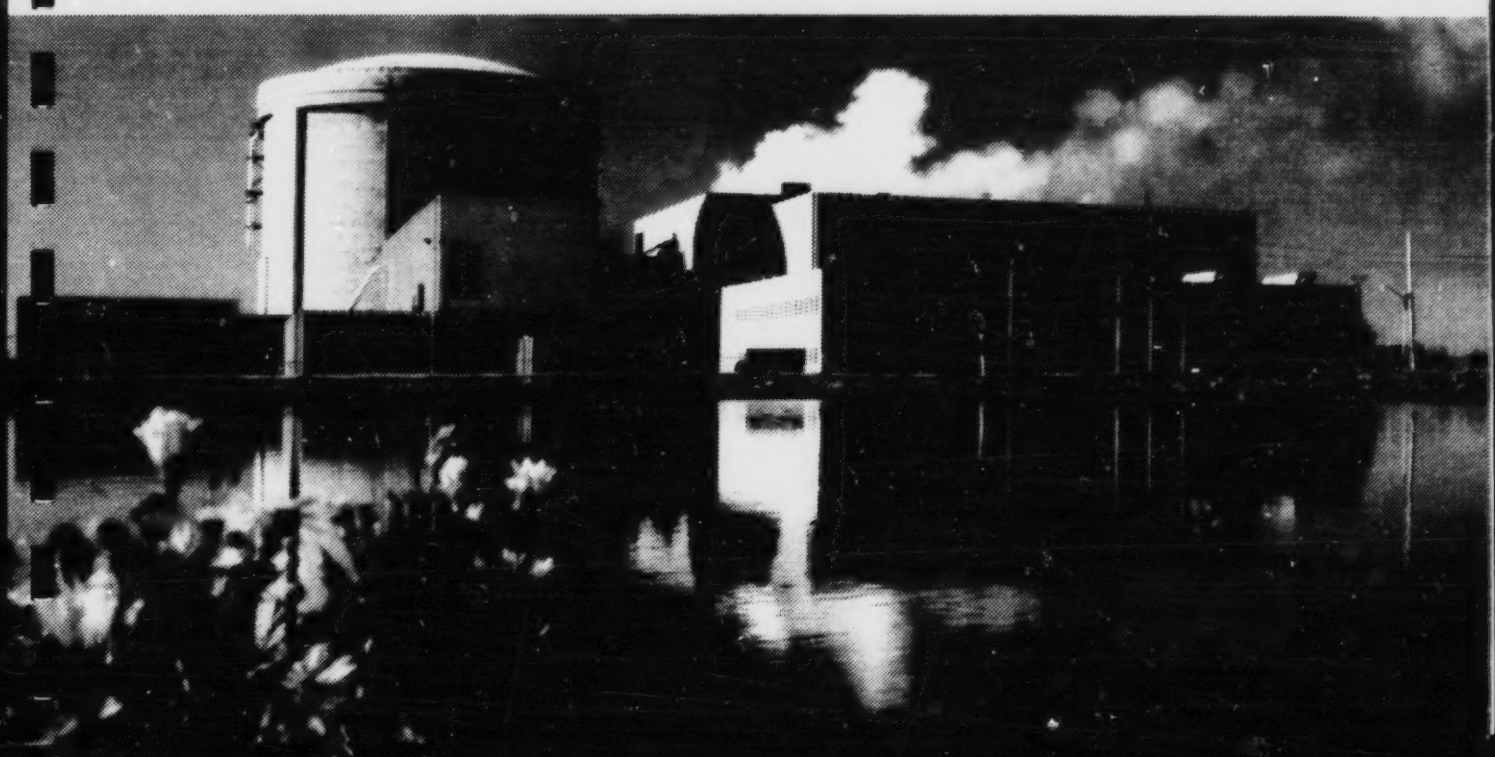
Énergie NB Power

Point Lepreau Generating Station

Environmental Radiation Monitoring Data for Point Lepreau Generating Station

January 1, 1998 to December 31, 1998



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Environmental Radiation Monitoring Data for Point Lepreau Generating Station

January 1, 1998 to December 31, 1998

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Executive Summary

This annual report is a compilation of the 1998 results from the Environmental Radiation Monitoring Program for the Point Lepreau Generating Station (PLGS).

Since 1976, the monitoring program has analysed more than 23 000 samples to define background radiation from natural and human sources. The contribution from human sources has declined significantly since atmospheric bomb tests have ceased. The program detected radionuclide fallout in New Brunswick after a Chinese atmospheric bomb test in 1980, and fallout from the accident at Chernobyl in 1986. There have been no regionally detectable releases of radiation from any human activity since these two events.

In 1998, there were 1755 analyses on 1253 samples to monitor environmental radiation around Point Lepreau and across the province in general. The analyses indicate that radiation dose from PLGS emissions continues to be well below the public dose limit (5000 microsieverts per annum), and also well below the operating target for nuclear power facilities in Canada (50 microsieverts per annum).

Source of Dose to Critical Group	*Individual Dose (μSv/a)*	*Population Dose (person-mSv/a)*
PLGS gaseous emissions	0.4	1.5
PLGS liquid emissions	0.2	0.8
natural background	2000	320000
medical procedures	-------	80000

The only assessable radiation dose from PLGS on the local population is that from tritiated water vapour in air. This continues to be detected offsite in air and water samples. The only significant upward trend in radionuclide levels, based on an analysis of all the data from previous years, was for tritium in Parshall Flume samples.

Population-dose is the summation of all calculated doses over the entire population within a 20 km radius from PLGS for the seafood pathway, and within a 60 km radius from PLGS for the airborne pathway. From radiation emissions, this population dose is 0.8 person-millisievert in the seafood pathway and about 1.9 person-millisieverts in the airborne pathway for a population total of 2.7 person-millisieverts. This is insignificant when compared with the population dose of about 320 000 person-millisieverts that this same group receives from natural background radiation and an additional 80 000 person-millisieverts received by some of this population from radiation used in medical treatments.

New sample types were officially added to the program this year (berries, surface water, precipitation and garden vegetables). These were informally collected in previous years, but their results were excluded from the report.

A leaking tritium EXIT sign that was delivered to the laboratory in late 1997 caused some

difficulties throughout 1998. Extra care was required in the handling and analysis of samples, and in the interpretation of results. By the end of the year, the contamination was no longer detectable in the lab.

The Quality Assurance (QA) program faced challenges this year from a reduction in blind samples from the United States Environmental Protection Agency (USEPA) and Atomic Energy of Canada Limited (AECL). This deficiency was balanced by an increase in other QA activity.

The objectives of the program were met. The program is currently under revision, with changes expected to be implemented in 1999 and described in the report for that year.

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1.0 Introduction

The licence to operate PLGS, issued by the Atomic Energy Control Board (AECB), requires that NB Power maintain an Operational Environmental Radiation Monitoring Program (OERMP) during normal plant operations. This document describes the 1998 results of the program.

The requirement for this program is stated in *Radiation Protection Directives*[1] and *Solid Radioactive Waste Management Facility 1991 Safety Report*[2]. The underlying reason for this is the large inventory of radionuclides that exist on site. The program operates in conjunction with *Liquid and Gaseous Effluent Monitoring Program*[3],which monitors and controls effluents at their source. The Derived Emission Limits (DELs) are calculated in *Derived Emission Limits for Radionuclides in Airborne and Liquid Effluents*[4].

Monitoring of the site began in 1976 with the Pre-operational Program[5], which became the OERMP in 1982[6] when PLGS was declared "in-service" in February, 1983. All radionuclide analyses were carried out in the Health Physics Environmental / Dosimetry Laboratory at 420 York Street, Fredericton, NB by the three full-time staff members (Health Physicist, Senior Technical Specialist and Technical Specialist).

The radiation monitoring program for PLGS is reviewed annually. This ensures that the samples collected, their frequency of collection, and the analytical techniques used are appropriate to achieve the objectives of the program. In 1999, the basis of the OERMP will be extensively revised to comply with *Guidelines for Radiological Monitoring of the Environment* [7], which did not exist when this program was first implemented.

The Environmental Radiation Monitoring Program for PLGS fulfils several objectives. These are to:

1) provide an early indication of the appearance or accumulation of any radioactive material in the environment caused by the operation of the station

2) verify the adequacy and proper functioning of station effluent controls and monitoring systems

3) provide an estimate of actual radiation exposure to the surrounding population

4) provide assurance to regulatory agencies and the public that the station's environmental impact is known and within operational targets.

5) provide standby monitoring capability for rapid assessment of risk to the general public in the event of unanticipated or accidental releases of radioactive material

6) allow an assessment of the Derived Emission Limit (DEL) calculations based upon empirical rather than theoretical data

The capability of the radiation monitoring laboratory is assessed through the QA program. This includes external programs offered by the USEPA and some laboratories in Canada. Analytical checks are also conducted daily. Indicator radionuclides, for example K-40 in milk, seawater and other samples, show that the analyses are reproducible and that the operation of the laboratory has not changed significantly since it began.

The following sections will briefly describe the program. Details are provided on PLGS emissions, analyses results, trends, dose estimates, and the quality assurance program.

2.0 Point Lepreau Emission Data

Table 2.01 lists the production performance for PLGS since its beginning. Experience has shown that the years of lower capacity factors are usually the years with the lowest airborne emissions of most radionuclides especially noble gases. The opposite is true for liquid emissions.

Table 2.01
PLGS Production Performance

Year	*Annual Gross Capacity Factor (%)*
1983	86
1984	90
1985	97
1986	94
1987	92
1988	96
1989	95
1990	96
1991	98
1992	87
1993	95
1994	94
1995	29
1996	83
1997	62
1998	68

Lifetime Gross Capacity Factor - 84

Emissions from PLGS continue to be at low levels as indicated in Table 2.02. By the time these releases reach the edge of the exclusion zone, they are diluted below the detection limits of most analysis procedures. Laboratory staff monitor the results of the emissions programs so that adjustments can be made to sampling and analyses protocols. There were no unusual emissions during 1998.

Table 2.02
Radionuclides Detected in Effluents

Nuclide	Gaseous Effluent DEL (Bq/a)	Release (Bq)	Liquid Effluent DEL (Bq/a)	Release (Bq)
H-3	4.3E+17	1.3E+14	1.6E+19	1.4E+14
C-14	3.3E+15	3.2E+11	3.0E+14	5.5E+09
Na-24	5.6E+15		----------	
Ar-41	6.4E+16	2.3E+12	----------	
Sc-46	1.7E+14		----------	
Cr-51	2.4E+16		2.2E+15	1.0E+07
Mn-54	1.1E+14		6.4E+13	4.3E+06
Fe-55	----------		5.1E+14	
Fe-59	4.0E+14		3.1E+13	2.0E+07
Co-58	3.0E+14		7.5E+13	
Co-60	6.5E+12	9.2E+05	1.8E+13	4.5E+08
Zn-65	7.1E+13		1.5E+13	
As-76	----------		3.2E+14	
Kr-85	1.10E+19		----------	
Kr-85m	5.20E+17	5.7E+10	----------	
Kr-87	9.40E+16	5.2E+09	----------	
Kr-88	2.80E+16	2.3E+10	----------	
Sr-89	3.70E+14		4.4E+16	
Sr-90	1.20E+13	2.3E+03	2.2E+15	6.0E+05
Y-90	8.20E+15		4.0E+15	
Y-91	----------		3.1E+15	
Zr-95	1.70E+14		3.7E+13	1.5E+08
Nb-95	1.30E+14	6.0E+04	1.1E+14	4.2E+08
Mo-99	5.40E+15		1.3E+16	6.8E+04
Ru-103	1.20E+15		1.8E+14	8.8E+04
Ru-106	7.70E+13		2.7E+14	
Ag-110m	3.80E+13		1.8E+13	1.6E+05
Sb-122	----------		1.8E+14	3.7E+06
Sb-124	2.50E+14		4.8E+13	7.0E+07
Sb-125	----------		1.9E+14	1.2E+07
Te-132	1.40E+15		2.9E+13	1.3E+05
I-123	----------		4.2E+16	
I-125	----------		2.3E+14	
I-129	----------		1.9E+13	
I-131	1.00E+13		1.7E+14	
I-132	1.50E+16		2.4E+16	
I-133	4.30E+14		2.3E+15	
I-134	1.90E+16		3.6E+17	
I-135	7.70E+15		9.2E+15	
Xe-131m	9.90E+18		----------	
Xe-133	2.40E+18	2.7E+12	----------	
Xe-133m	2.80E+18		----------	
Xe-135	3.40E+17	1.1E+12	----------	
Xe-135m	2.00E+17	1.6E+10	----------	
Xe-138	2.20E+16	1.3E+10	----------	
Cs-134	1.90E+13		2.5E+14	
Cs-135	----------		3.4E+15	
Cs-136	----------		6.3E+14	
Cs-137	5.40E+12	1.5E+05	4.0E+14	1.3E+07
Ba-140	7.40E+14		9.4E+15	
La-140	1.10E+16		4.7E+14	
Ce-141	2.10E+15		7.4E+14	
Ce-144	1.10E+14		2.8E+14	
Np-239	1.00E+16		----------	
Noble Gas	7.30E+16		----------	
Xe-137	----------	4.2E+10	----------	
Gd-153	----------		----------	3.7E+07
Tb-160	----------		----------	3.0E+07
Alpha	----------		----------	2.6E+07
Beta	----------		----------	1.7E+08

3.0 Sample Media, Locations and Frequency

The data contained in this report are for samples collected from January 1 to December 31, 1998, with some overlap for air and TLD samples. During this time, the major media analysed and their frequency of collection were as indicated in Table 3.01. Sample collection usually takes place at least once each week throughout the year. The number of each sample type and the major radionuclide measurements performed are listed in Table 3.02.

The miscellaneous samples include those which do not readily fit into any of these listed categories or are not routinely collected. These include numerous in-station samples (e.g. drinking water) relating to the operation of PLGS.

The major sample locations are listed in Table 3.03 (details in Appendix C) and shown in Figures 3.01 to 3.04. Each "Indicator" site has a three or four-character identification code (e.g., F01, I00A). An Indicator site is one within the possible influence of PLGS emissions. "Reference" locations, chosen to lie outside the influence of PLGS operations, are identified by the letter R at the end of the location code (e.g., A01R).

Sample locations for mobile seafood species (lobster, fish, etc.) caught in the Point Lepreau area are specified as accurately as reasonably possible. The location of capture, however, may bear little relationship to where the animal has been in the recent past. The availability of such samples is not generally predictable and is outside of the control of the laboratory.

Table 3.01
Schedule Of Sample Collection And Analysis

Sample Media	*Typical Frequency*
Atmospheric Monitoring	
Airborne Particulates	Monthly (Integrated sample)
Airborne Radioiodines	Monthly (Integrated sample)
Airborne Tritium	Monthly (Integrated sample)
Airborne C-14	Monthly (Integrated sample)
Ambient Gamma (TLDs)	Quarterly (Integrated sample)
Airborne Radiostrontiums (GEM)	Weekly (Integrated sample)
Terrestrial Monitoring	
Milk - commercial dairy	Monthly
- dairy farms	Quarterly
Well Water	Semi-annually
Other Water	Quarterly
Ambient Gamma (TLDs)	Quarterly (Integrated sample)
Berries	As Available
Garden Vegetables	As Available
Vegetation	Quarterly
Soil	Quarterly
Precipitation	Monthly (Integrated sample)
Marine Monitoring	
Sea Water	Quarterly
Clams	As Available
Fish	As Available
Lobster	As Available
Periwinkles	As available
Aquaculture Salmon	As Available
Scallops	As Available
Dulse	As Available
Other Sea Plants	Quarterly
Sediment	Quarterly
Gamma Surveys (Beaches)	Quarterly
Liquid Sr-90 (LEM)	Monthly (Integrated sample)
Solid Radioactive Waste Management Facility	
Bore Holes	Quarterly
Parshall Flumes	Weekly
Ambient Gamma (TLDs)	Quarterly (Integrated sample)

Table 3.02
Sample Information

Sample Media	*Number of Samples*	*Radionuclide Measurement*
Atmospheric Monitoring		
Airborne Particulates	96	gamma emitters & gross alpha/beta
Airborne Radioiodines	96	radioiodines
Airborne Tritium	94	H-3
Airborne Carbon-14	36	C-14
Ambient Gamma (TLDs)	163	gamma exposure
Airborne Radiostrontiums (GEM)	52	Sr-89,90
Terrestrial Monitoring		
Milk	22	gamma emitters & H-3
Well Water	22	gamma emitters, gross alpha/beta, H-3
Other Water	14	gamma emitters & H-3
Ambient Gamma (TLDs)	see *Atmospheric Monitoring*	gamma exposure
Berries	12	gamma emitters
Garden Vegetables	29	gamma emitters
Vegetation	18	gamma emitters
Soil	10	gamma emitters
Precipitation	36	gamma emitters & H-3
Marine Monitoring		
Sea Water	28	gamma emitters & H-3
Clams	6	gamma emitters
Fish	3	gamma emitters
Lobster	8	gamma emitters
Aquaculture Salmon	3	gamma emitters
Scallops	2	gamma emitters
Dulse	15	gamma emitters
Other Sea plants	19	gamma emitters
Sediment	40	gamma emitters
Gamma Surveys (Beaches)	40	gamma dose rate
Liquid Radiostrontiums (LEM)	12	Sr-89,90
Solid Radioactive Waste Management Facility		
Bore Holes	62	gamma emitters & H-3
Parshall Flumes	104	gamma emitters & H-3
Ambient Gamma (TLDs)	172	gamma exposure
Other		
Miscellaneous	80	as required
Quality Assurance	5	as required

Each sample site has a unique location code associated with it. It is usually made up of a letter and a two digit number. There are some exceptions to this, especially for in-plant samples. Also, an additional letter ("R") is added to those location codes that represent reference sites. Table 3.03 is a list of the general areas represented by the first letter. Specific locations and their codes are found in detail in Appendix C.

Table 3.03
General Location Codes

A	west of Pennfield Ridge
B	Pennfield to New River Beach (inclusive)
C	Lepreau and Lepreau Harbour
D	Little Lepreau and Little Lepreau Basin
E	Maces Bay
F	Welch Cove
G	Pt. Lepreau lighthouse and surrounding area
H	Duck Cove
I	PLGS site - north-east quadrant
J	PLGS site - south-east quadrant
K	PLGS site - south-west quadrant
L	PLGS site - north-west quadrant
M	PLGS
N	Dipper Harbour
P	east of Dipper Harbour East to Musquash
Q	Lorneville
S	Saint John and surrounding area
T	Taymouth
X	Fredericton and surrounding area

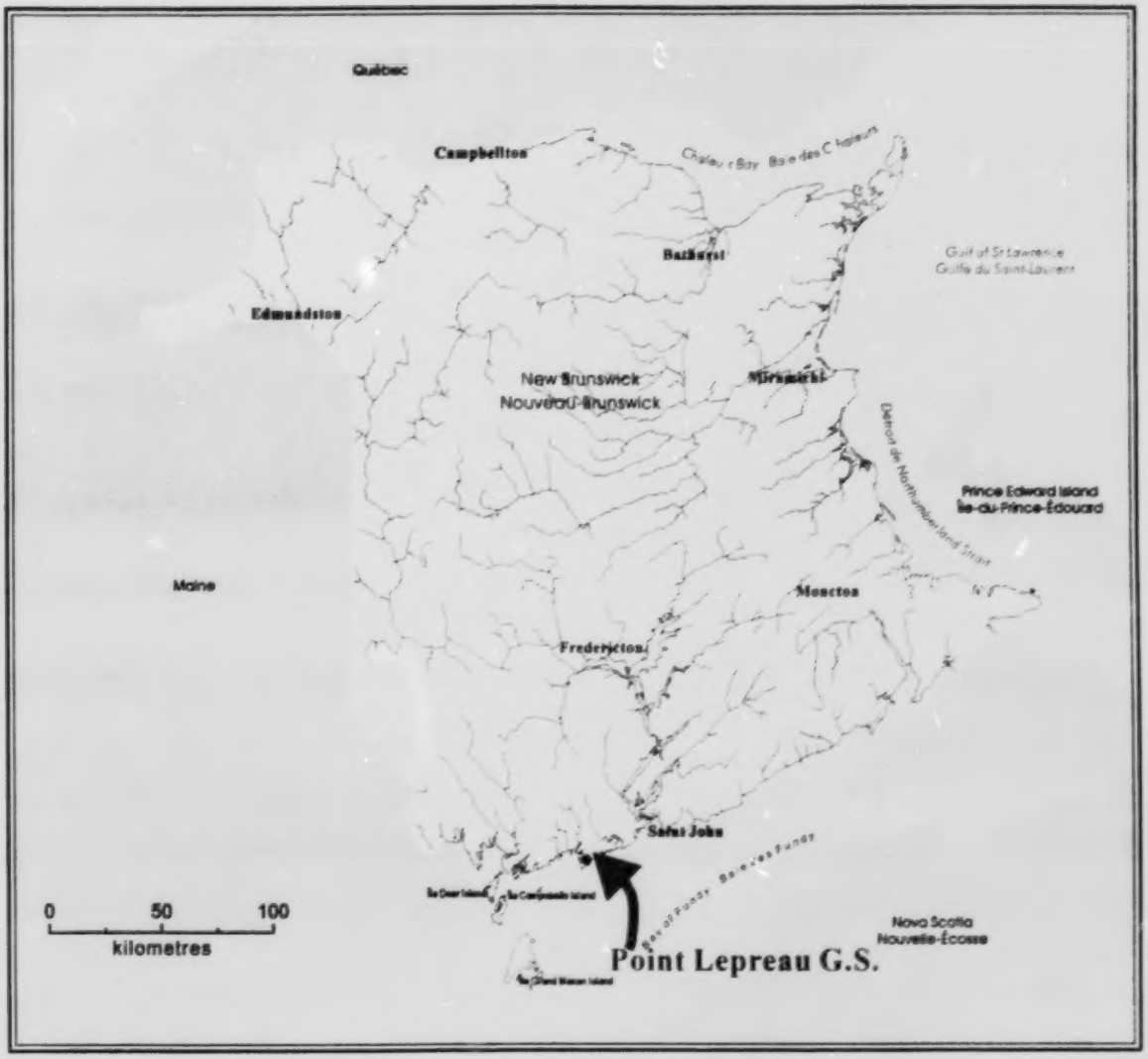


Figure 3.01
Map of New Brunswick

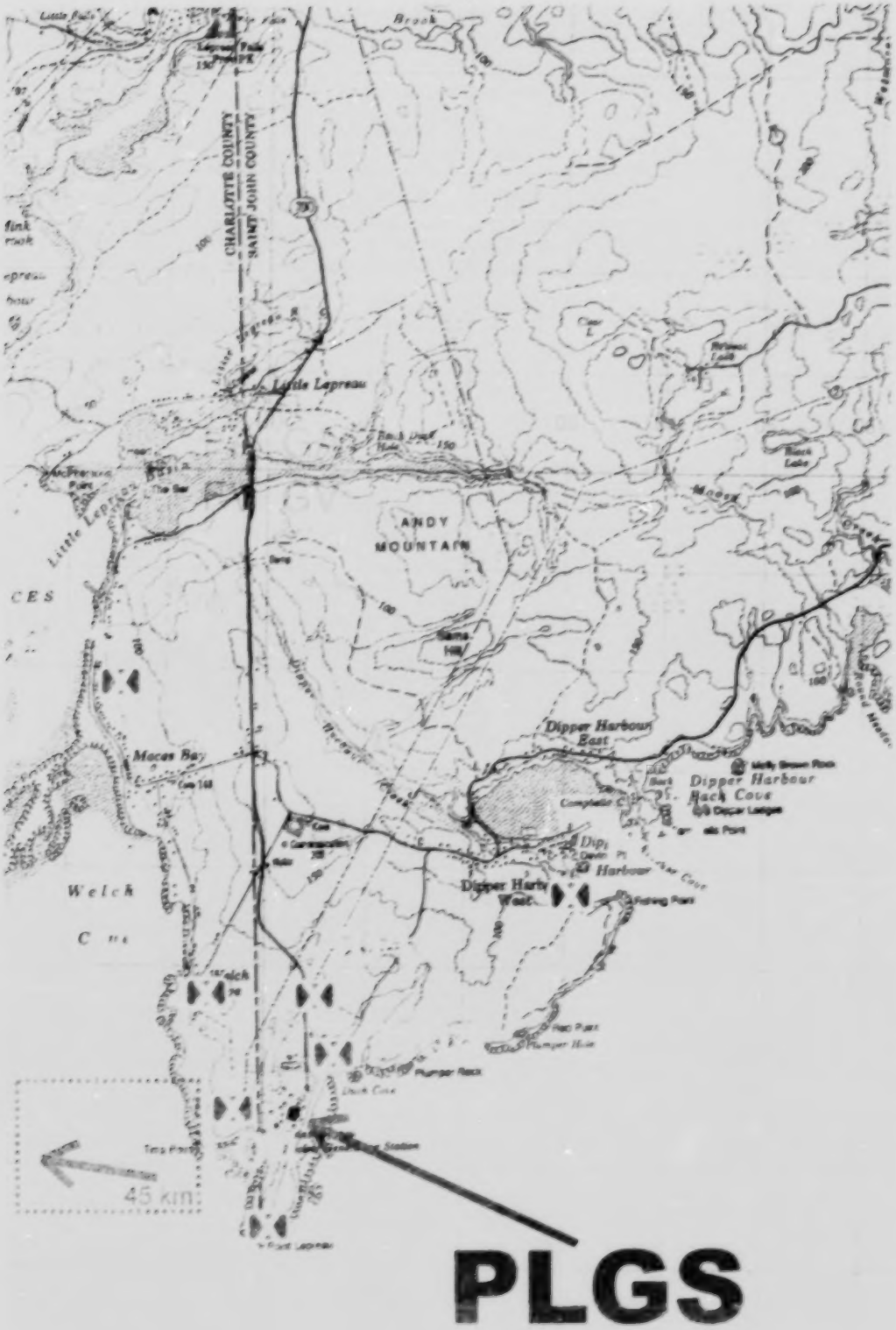


Figure 3.02
Air Monitoring Stations

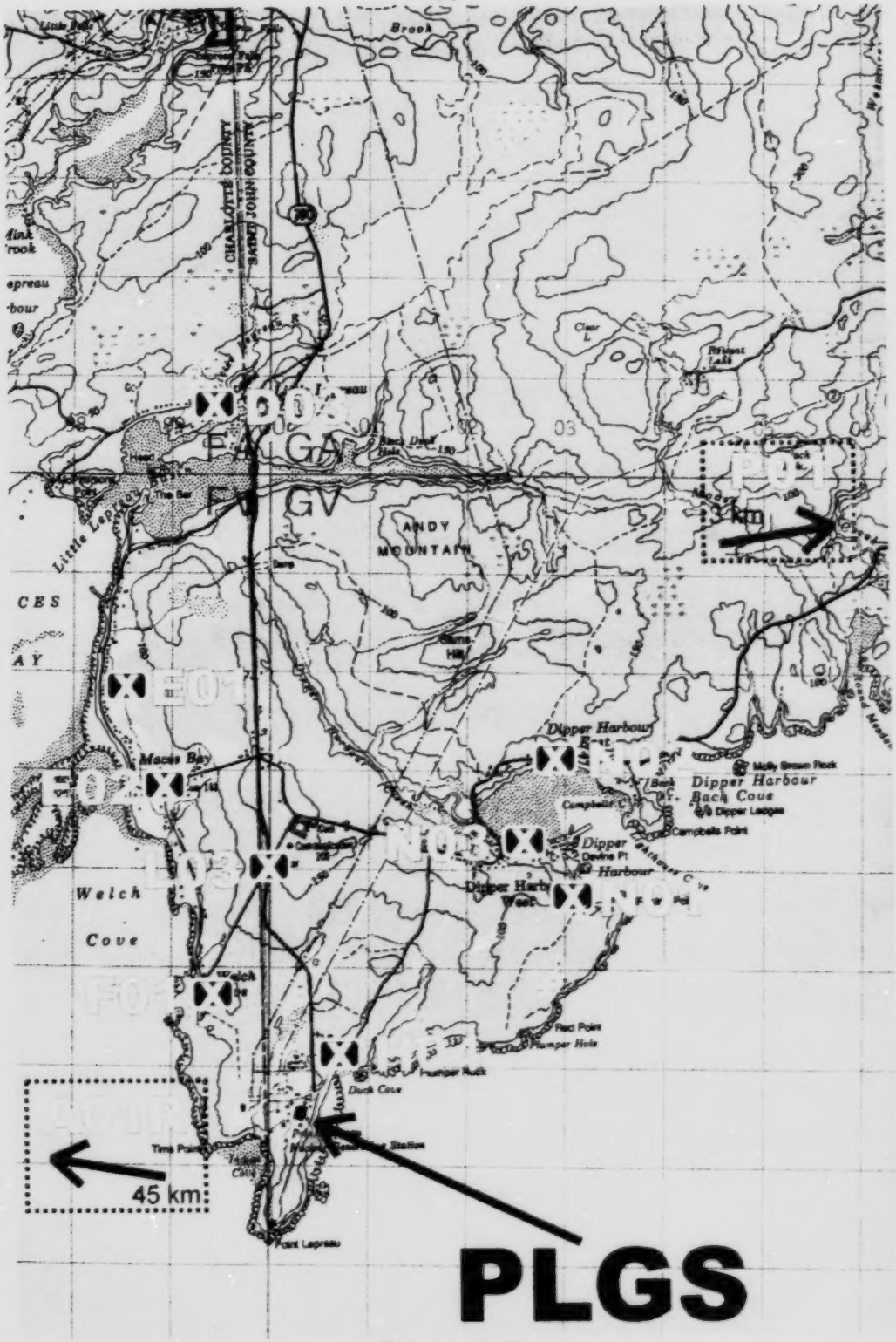


Figure 3.03
Well Water Sites

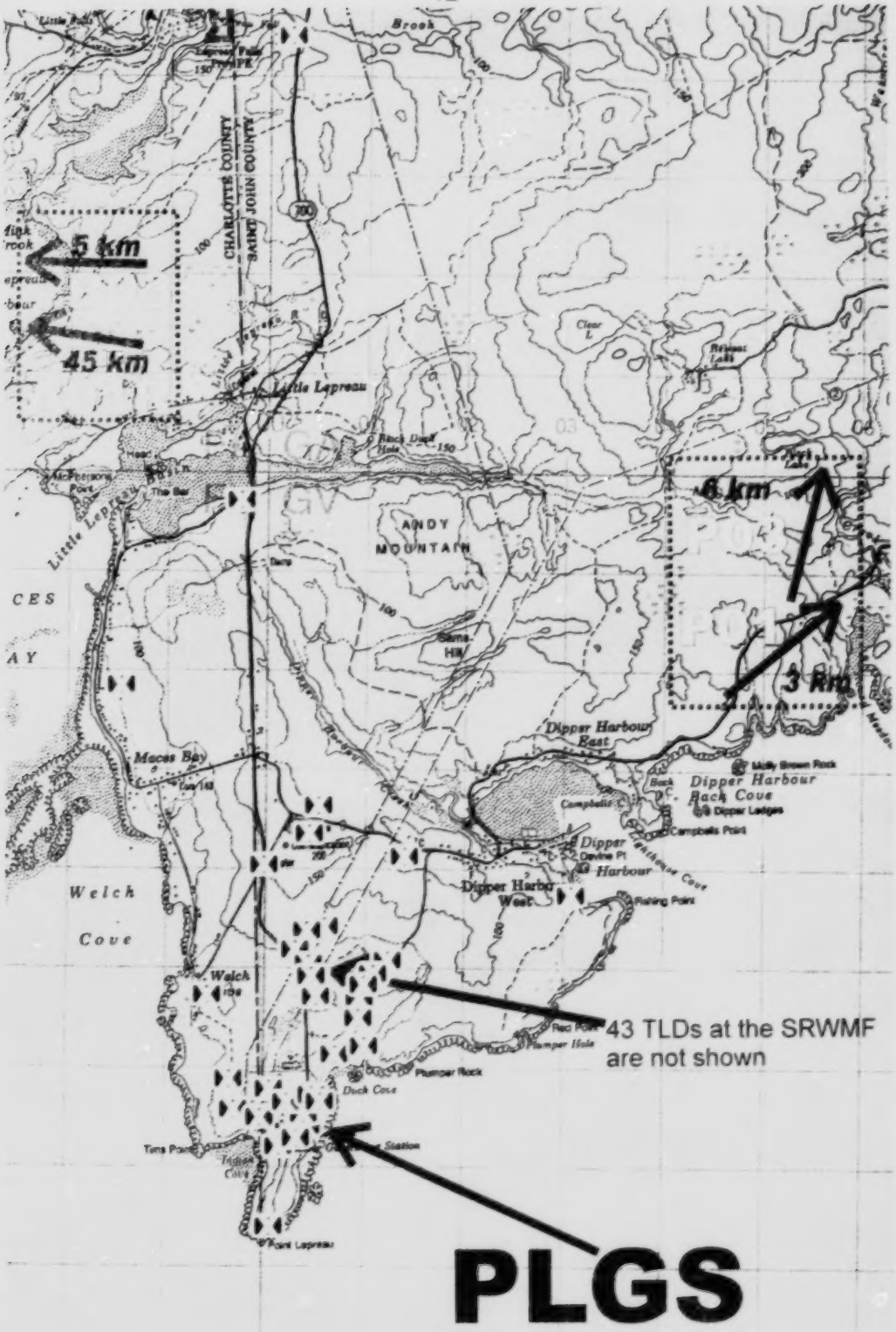


Figure 3.04
TLD Sites

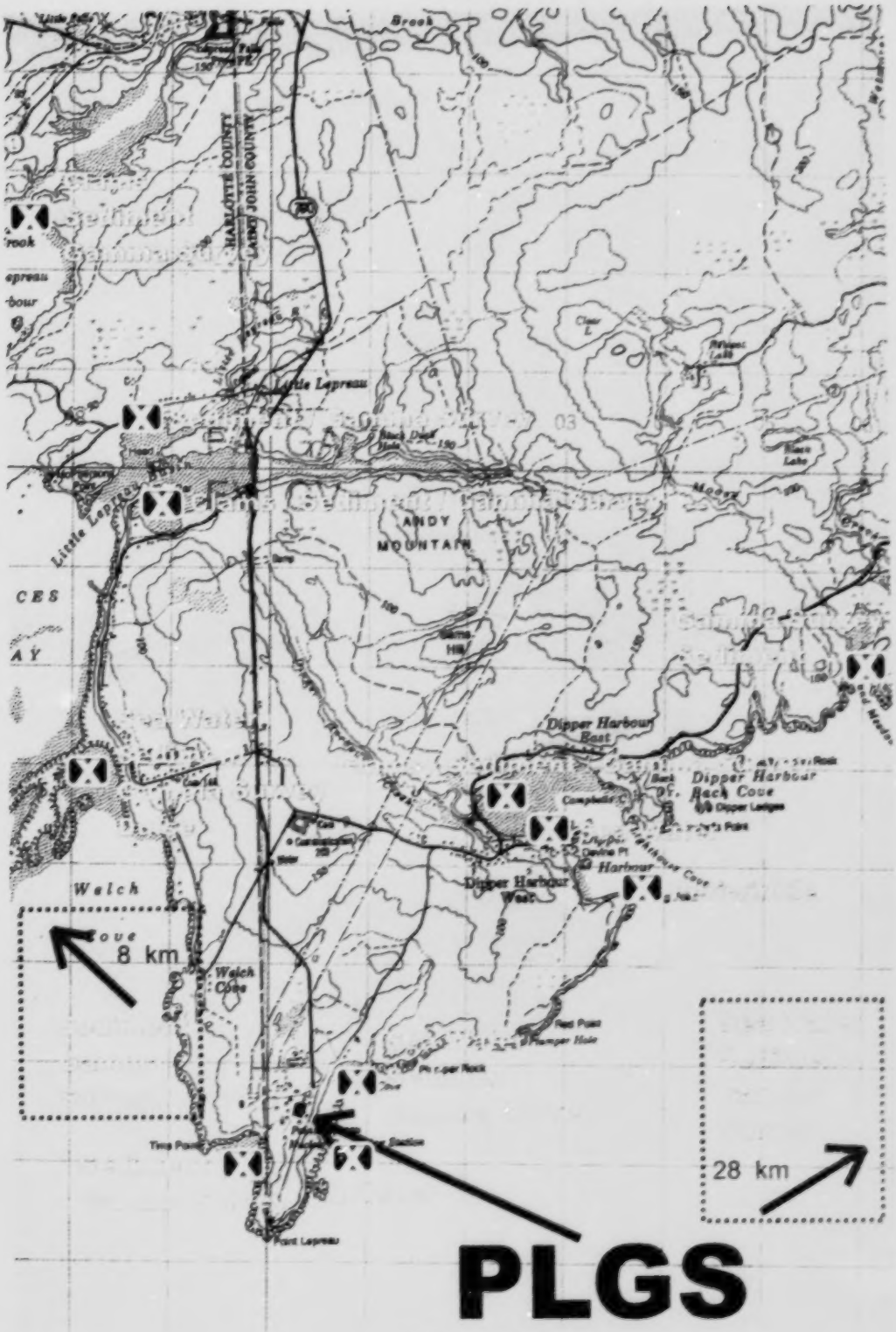


Figure 3.05
Marine Monitoring Sites

4.0 Summary and Discussion Of Data

The following is a summary and discussion of the data on environmental samples collected for 1998.

Most samples contained detectable levels of naturally occurring (i.e. K-40) or cosmogenic (i.e. Be-7) radionuclides. Some contained Cs-137 (soils, sediments, lichen) from the atmospheric bomb tests of past years and the Chernobyl accident. The only radionuclide originating from PLGS that is detected consistently is tritium (in air, fresh water and seawater). In 1998, environmental samples which contained detectable radionuclides emitted from PLGS were:

1) airborne water vapour, freshwater and seawater samples (H-3)

2) two air samples containing C-14 at levels close to the detection limit

3) Parshall flume and bore hole waters from the Solid Radioactive Waste Management Facility (SRWMF) (H-3)

4) some TLD measurements from onsite locations (at the SRWMF and close to the stack).

The natural concentration of H-3 in most surface waters lies between about 0.2 and 0.7 becquerel (Bq)/L. The natural concentration of C-14 in the atmosphere is about 0.3 Bq/g of carbon. Such levels are usually below the lower limit of detection of the extremely sensitive analytical methods used in the monitoring program. Detectable values usually indicate additional contributions from the operation of PLGS.

Outside the 1 km boundary, the activity of H-3 in air ranges from the natural H-3 content in air of less than about 0.02 Bq/m^3 (i.e., less than the lower limit of detection by the method used) up to about 0.4 Bq/m^3 of air.

Only detected radionuclides are listed in the following tables. Refer to Tables 1 to 11 in Appendix A for detailed listings of detection limits. Most tables contain the following data:

Column 1 - Shows the type of analysis or nuclide and, in parentheses, the total number of samples analysed.

Column 2 - Shows the mean of the Critical Levels (CLs) for all samples and, in parentheses, the range of the CLs. Any measurement greater than the CL is considered detected at the 99% confidence level (an explanation of the statistical protocol is given in Appendix A).

Column 3 - Shows the mean of the detected values (i.e., values exceeding the CL) for all Indicator stations, followed in parentheses by the ratio (F) of the number of detected values to the total number of Indicator samples. The second line of the column indicates the range of detected values for the Indicator stations.

Column 4 - Shows the location code for the Indicator station with the largest mean value. Refer to Appendix C for sample locations.

Column 5 - Shows the mean of detected values for the Indicator station with the largest value, followed in parentheses by the ratio (F) of the number of detected values to the total number of samples for this Indicator station. The second line of this column contains the range of detected values for this location.

Column 6 - Shows the mean of detected values at the Reference location(s), followed in parentheses by the ratio (F) of detected values to the total number of samples at this location. The second line of this column contains the range of detected values for the Reference location(s).

4.1 Airborne Particulates

In 1998, there were no detectable airborne particulate radionuclides that could be attributed to the operation of PLGS on any of the 96 samples analysed.

Air is continuously monitored from the eight locations shown in Figure 3.02. Once a month the filters are changed and analysed. Although 96 filters were processed, some of them do not represent a full month of collection due to mechanical or electrical problems. This manifests itself in higher LLDs for those lower volume samples. A total of 120 location days were lost (out of 2920).

Gross alpha and gross beta measurements are an indication of total activity in the environment. This includes naturally occurring, cosmogenic (e.g., beryllium-7), and man-made sources of radiation. Table 4.01 is a summary of detected radionuclides. Figures 4.01 and 4.02 show the gross beta results for each location. While there is a slight seasonal trend, there is no difference between onsite and offsite results.

Table 4.01
Airborne Particulates
(Bq/m^3)

Analysis Type (Total Number)	Critical Level Mean (Range)	Indicator Stations Mean (F) (Range)	Highest Indicator Station Location	Mean (F) (Range)	Reference Station Mean (F) (Range)
ALPHA (96)	3.3E-06 (9.1E-07 - 2.2E-05)	2.4E-05 (83/84) (5.1E-06 - 6.0E-05)	G02	3.6E-05 (11/12) (1.6E-05 - 6.0E-05)	2.9E-05 (12/12) (1.0E-05 - 7.9E-05)
BETA (96)	8.3E-06 (2.2E-06 - 4.8E-05)	2.7E-04 (84/84) (5.3E-05 - 5.9E-04)	G02	3.5E-04 (12/12) (1.3E-04 - 5.9E-04)	3.1E-04 (12/12) (1.3E-04 - 5.4E-04)
Be-7 (96)	3.1E-04 (3.5E-05 - 1.7E-03)	2.0E-03 (72/84) (5.4E-04 - 4.3E-03)	G02	3.1E-03 (8/12) (1.2E-03 - 4.3E-03)	2.4E-03 (12/12) (8.1E-04 - 4.4E-03)

F : Number of analyses greater than the Critical Level/Total number of analyses

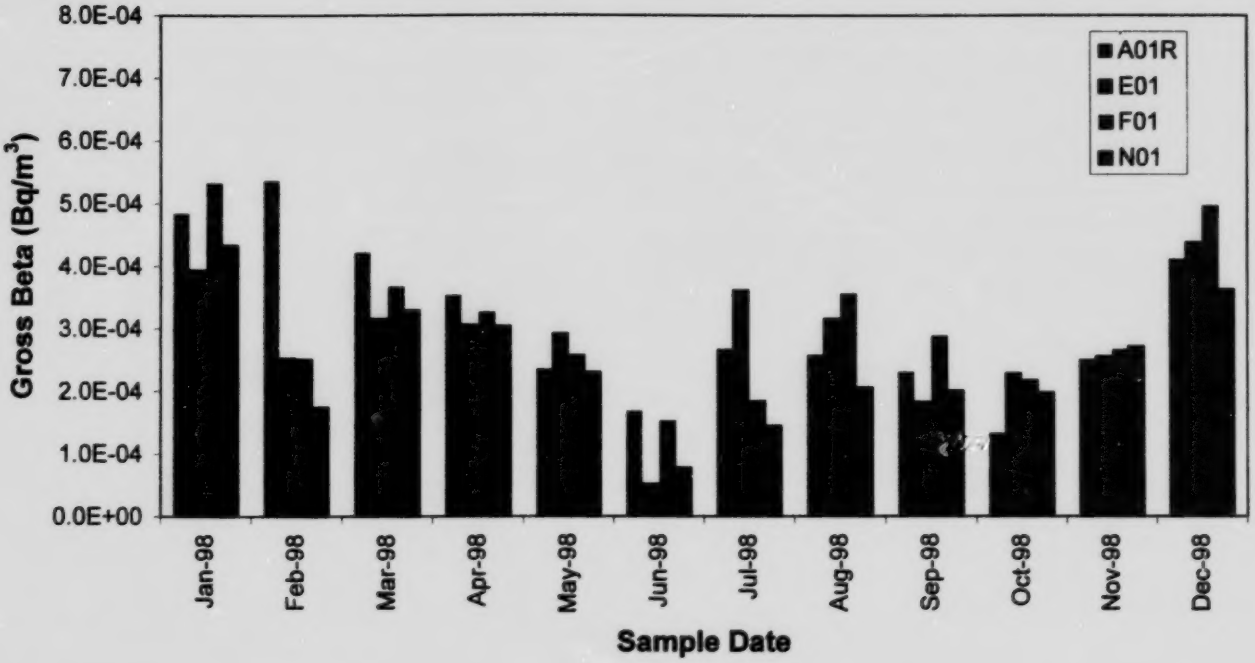


Figure 4.01
Gross Beta in Air for Each Offsite Air Station

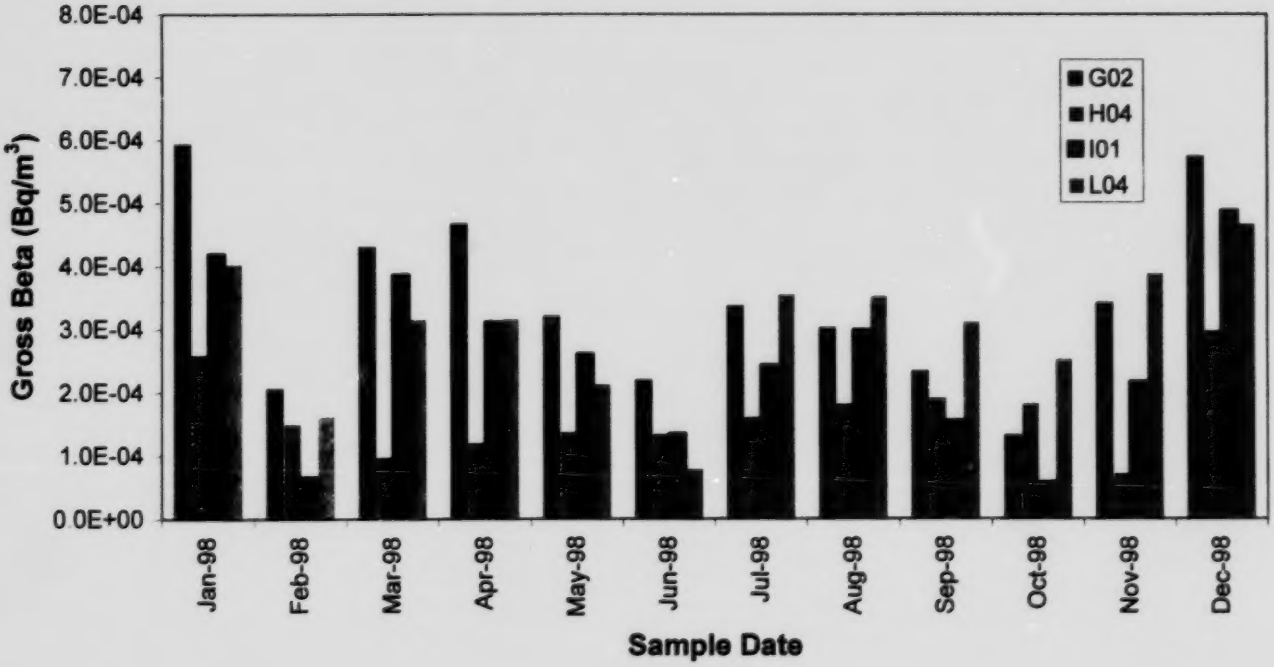


Figure 4.02
Gross Beta in Air for Each Onsite Air Station

4.2 Airborne Radioiodines

Iodine-131 was consistently below the Critical Level (9E-5 Bq/m^3) on the 96 samples analysed.

Air is continuously monitored from the eight locations shown in Figure 3.02. Once a month the cartridges are changed and analysed. Although 96 fcartridges were processed, some of them do not represent a full month of collection due to mechanical or electrical problems. A total of 120 location days were lost (out of 2920).

4.3 Airborne Tritium

Tritium was detected in 72 of the 84 samples collected from the air monitoring stations on the Point Lepreau peninsula in 1998, and was detected in four of the 11 samples at the reference location.

Air is continuously monitored from the eight locations shown in Figure 3.02. Once a month the molecular sieve bombs are changed and analysed. Although the results for 94 samples were reported, some of them do not represent a full month of collection due to mechanical or electrical problems. This manifests itself in higher LLDs for those lower volume samples. A total of 120 location days were lost (out of 2920).

The maximum concentration of tritium in air on site was less than 8 Bq/m^3 of air. Off site it reached 0.4 Bq/m^3. Tritium has been detected from time to time at the reference location, even before PLGS became operational.

One sample (from the Reference location) was rejected due to H-3 contamination from the leaking EXIT sign. Table 4.02 is the summary table of 1998 tritium data and Table 4.03 gives details of 1998 tritium results by location (also shown in Figures 4.03 and 4.04).

Table 4.02
Airborne Tritium
(Bq/m^3)

Analysis Type (Total Number)	Critical Level Mean (Range)	Indicator Stations Mean (F) (Range)	Highest Indicator Station Location	Mean (F) (Range)	Reference Station Mean (F) (Range)
H-3 (95)	4.7E-02 (2.1E-02 - 1.2E-01)	7.7E-01 (72/84) (4.3E-02 - 7.4E+00)	I01	1.5E+00 (12/12) (8.3E-01 - 2.5E+00)	9.3E-02 (4/11) (4.0E-02 - 1.6E-01)

F : Number of analyses greater than the Critical Level/Total number of analyses.

Table 4.03
Airborne Tritium
(Bq/m^3)

Collection Start Date	A01R Bocabec ## 45	E01 Maces Bay 4.5	F01 Welch Cove 1.5	G02 Lepreau Lighthouse 1.0	H04 Information Centre 0.75	I01 SRWMF 1.0	L04 Construction Stores 0.6	N01 Dipper Harbour 3.8
98-01-11	4.8E-02	< 3.7E-02	1.6E-01	1.1E+00	5.8E-01	1.9E+00	3.7E-01	9.5E-02
98-02-11	NA	< 4.4E-02	1.5E-01	5.5E-01	6.1E-01	1.4E+00	7.4E+00	1.6E-01
98-03-10	1.6E-01	< 3.6E-02	< 5.7E-02	4.1E-01	8.5E-01	1.1E+00	2.8E-01	9.9E-02
98-04-07	4.0E-02	< 6.2E-02	5.7E-02	5.4E-02	1.7E+00	8.3E-01	4.7E-01	2.1E-01
98-05-05	< 5.2E-02	8.9E-02	2.6E-01	2.0E-01	2.2E+00	1.0E+00	1.1E+00	3.7E-01
98-06-04	< 5.1E-02	9.5E-02	1.5E-01	2.9E-01	1.2E+00	1.3E+00	8.5E-01	3.3E-01
98-06-30	1.3E-01	< 4.7E-02	2.1E-01	< 4.8E-02	2.1E+00	1.7E+00	6.1E-01	4.1E-01
98-08-12	< 1.4E-01	< 6.0E-02	1.5E-01	6.6E-01	1.6E+00	2.5E+00	4.8E-01	2.5E-01
98-09-10	< 9.8E-02	9.3E-02	< 1.4E-01	1.8E-01	2.1E+00	1.9E+00	1.7E-01	1.3E-01
98-10-07	< 9.7E-02	8.5E-02	< 7.0E-02	6.8E-01	1.3E+00	2.3E+00	1.1E-01	8.6E-02
98-11-03	< 5.3E-02	< 7.3E-02	1.5E-01	1.5E-01	8.0E-01	1.3E+00	4.3E-02	9.0E-02
98-12-03	< 2.9E-02	< 2.7E-02	1.2E-01	3.2E-01	8.3E-01	1.3E+00	6.3E-01	1.0E-01

: Approximate distance from Point Lepreau G.S. (km).
NA : Data Not Available - A sample was not collected at this location during the period.

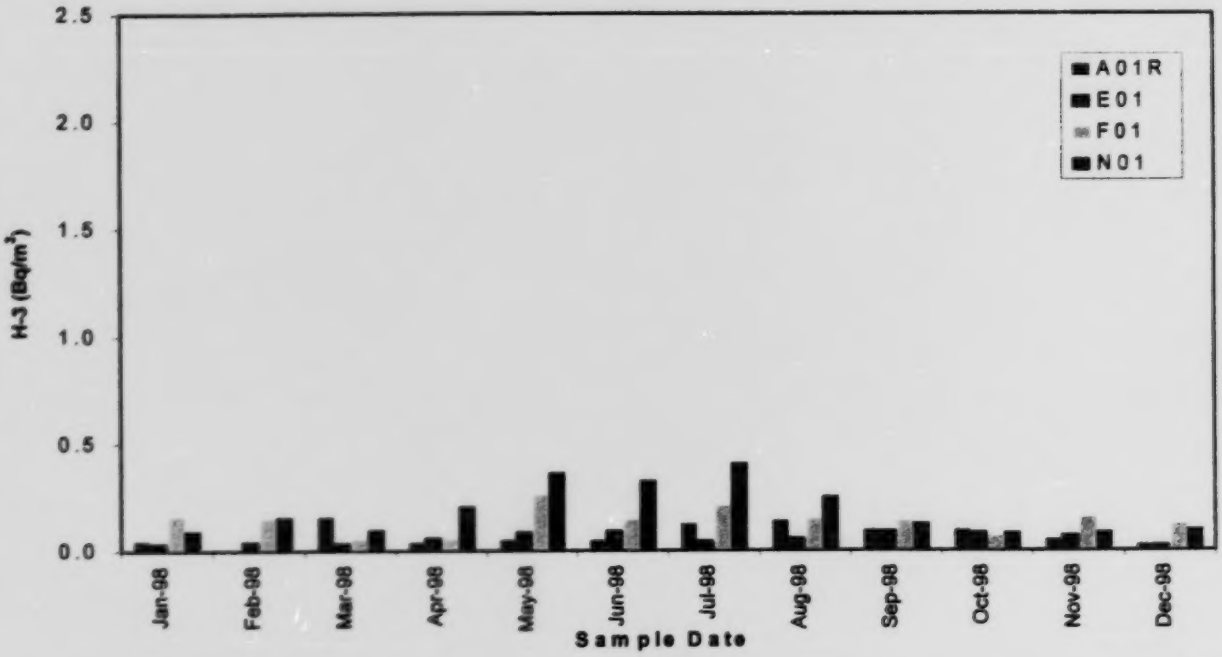


Figure 4.03
Airborne Tritium for Each Offsite Air Station

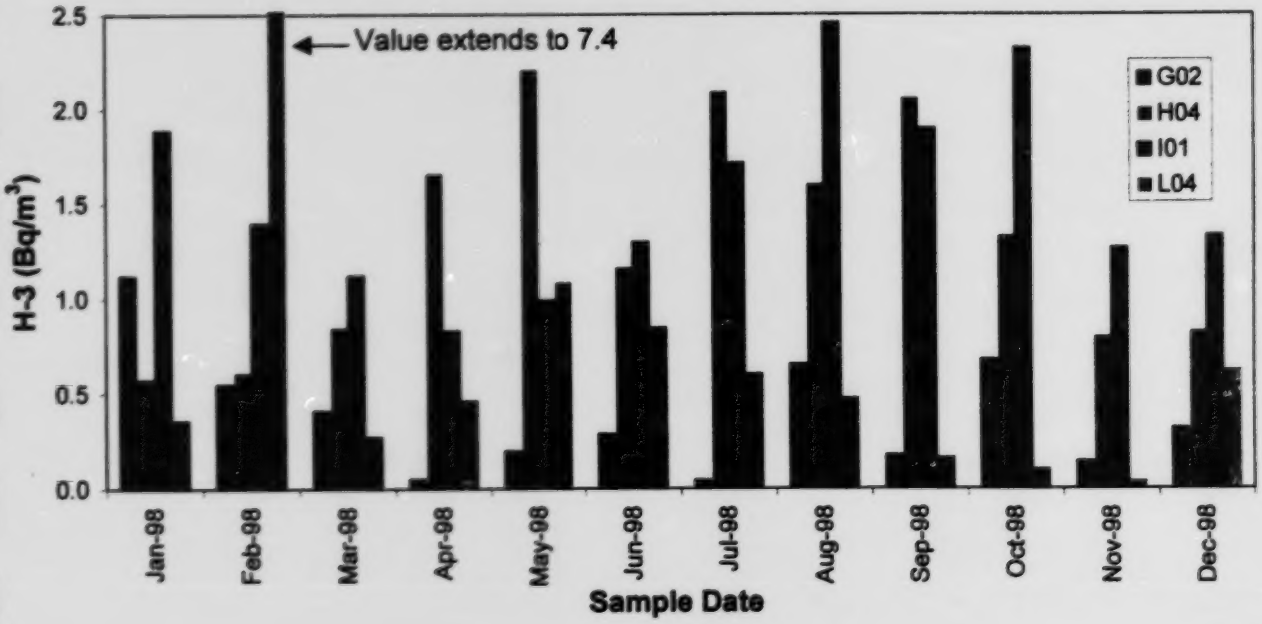


Figure 4.04
Airborne Tritium for Each Onsite Air Station

4.4 Airborne Carbon-14

Out of 36 samples collected in 1998, there were two detectable values (0.32 and 0.22 Bq/m^3) for C-14.

Air is continuously monitored at two onsite locations (G02 and H04 in Figure 3.02) and one reference location. The caustic bubblers are changed monthly and returned to the lab for analyses. One sample was impacted due to equipment failure (a high LLD due to the low sample volume).

Results for 1998 are summarised in Table 4.04. Individual analyses are given in Table 4.05. The detected values were comparable with typical LLDs for this nuclide. The calculated average annual concentration of C-14 in air at the boundary fence for 1998 was approximately 9E-4 Bq/m^3 (well below the typical lower limit of detection for C-14 at this time). A more sensitive method will be introduced in 1999 which will decrease the LLD by at least a factor of ten.

Table 4.04
Airborne Carbon-14
(Bq/m^3)

Analysis Type (Total Number)	Critical Level Mean (Range)	Indicator Stations Mean (F) (Range)	Highest Indicator Station Location	Mean (F) (Range)	Reference Station Mean (F) (Range)
C-14 (36)	3.4E-01 (1.5E-01 - 4.1E+00)	2.7E-01 (2/24) (2.2E-01 - 3.2E-01)	H04	3.2E-01 (1/12) (3.2E-01 - 3.2E-01)	*

* : The activity is less than or equal to the Critical Level (99% Confidence Level).

F : Number of analyses greater than the Critical Level/Total number of analyses

Table 4.05
Airborne Carbon-14
(Bq/m^3)

Collection Start Date +	G02 Lepreau Lighthouse	H04 Information Centre	X03R Fredericton Laboratory
98-01-11	< 1.8E-01	< 1.9E-01	< 2.1E-01
98-02-11	< 1.8E-01	< 2.0E-01	< 2.0E-01
98-03-10	< 2.2E-01	< 2.5E-01	< 2.0E-01
98-04-07	< 2.8E-01	< 1.9E-01	< 2.5E-01
98-05-05	2.2E-01	3.2E-01	< 4.9E-01
98-06-04	< 3.3E-01	< 3.0E-01	< 6.9E-01
98-06-30	< 5.0E+00	< 2.1E-01	< 2.8E-01
98-08-12	< 5.2E-01	< 3.5E-01	< 2.5E-01
98-09-10	< 2.4E-01	< 3.4E-01	< 2.1E-01
98-10-07	< 2.4E-01	< 3.3E-01	< 2.3E-01
98-11-03	< 2.0E-01	< 2.5E-01	< 3.1E-01
98-12-03	< 1.6E-01	< 2.5E-01	< 5.1E-01

+ : The sample collection periods are approximately four weeks in duration, so there are either 12 or 13 periods in the year. The two indicator stations are changed at the same time.
NA : Data Not Available - A sample was not collected at this location during the period.

4.5 Ambient Gamma (TLD)

Gamma exposure measurements were slightly higher onsite, especially near the SRWMF and reactor building, than they were offsite.

Ambient gamma radiation is measured by thermoluminescent dosimeters (TLDs) at the 84 locations shown in Figure 3.04. Forty three of these are near the Solid Radioactive Waste Management Facility. Locations I00A - I00L are on the perimeter fence of the SRWMF-Phase 1, and locations I03A -I03L are on the perimeter of the SRWMF-Phase 2. TLDs are changed quarterly. All of the 335 dosimeters placed in the environment around Point Lepreau were recovered.

Data for 1998 are given in Table 4.06. The data in the "Total" column are rounded to the nearest ten microgray. If a quarterly measurement is not available (lost or vandalised TLD, animal damage, moisture penetration, etc.) a mean value is calculated from the available measurements in order to provide an estimate for the annual total. The statistical uncertainty shown in the Total column is the square root of the sum of the squares of the

uncertainties of the individual quarterly measurements.

The variation in natural background radiation at any individual location covers a range of about 300 microgray from year to year. A few locations close to the reactor building (e.g. J70) and the air emissions stack show significant, but small, increases in gamma radiation due to chronic releases of low levels of noble gases. Small increases at the SRWMF locations are due to low-level Waste and used fuel emplacement, and not to station emissions. There is a small, but undefinable, component of radiation on the TLDs at the SRWMF that is due to enhanced natural radiation from the aggregate in the concrete structures.

Figure 4.06 compares the reference location results with the results for other locations.

The range of values for the 12 TLD locations at the SRWMF (Phase 2) was from 720 to 1420 microgray per annum. The average for the facility is 860 microgray per annum - not significantly different from other low background (and natural) radiation measurements anywhere in Canada.

Table 4.06
TLD, Environmental
(μGy ± 10%)

Location	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total
A01R	136 +- 14	185 +- 19	167 +- 17	162 +- 16	650 +- 30
B03	147 +- 15	198 +- 20	173 +- 17	167 +- 17	690 +- 30
C03	124 +- 12	185 +- 18	170 +- 17	160 +- 16	640 +- 30
D02	146 +- 15	212 +- 21	186 +- 19	185 +- 18	730 +- 40
E01	133 +- 13	167 +- 17	168 +- 17	155 +- 16	620 +- 30
E04	124 +- 12	197 +- 20	178 +- 18	162 +- 16	660 +- 30
E05	129 +- 13	183 +- 18	169 +- 17	171 +- 17	650 +- 30
E06	195 +- 20	241 +- 24	NA	207 +- 21	860 +- 40
F01	116 +- 12	135 +- 13	141 +- 14	144 +- 14	540 +- 30
G02	208 +- 21	194 +- 19	197 +- 20	198 +- 20	800 +- 40
H04	146 +- 15	163 +- 16	159 +- 16	159 +- 16	630 +- 30
H05	107 +- 11	159 +- 16	138 +- 14	135 +- 13	540 +- 30
I00A	213 +- 21	258 +- 26	234 +- 23	238 +- 24	940 +- 50
I00B	222 +- 22	269 +- 27	240 +- 24	249 +- 25	980 +- 50
I00C	206 +- 21	261 +- 26	239 +- 24	247 +- 25	950 +- 50
I00D	207 +- 21	260 +- 26	222 +- 22	228 +- 23	920 +- 50
I00E	209 +- 21	249 +- 25	221 +- 22	233 +- 23	910 +- 50
I00F	210 +- 21	247 +- 25	237 +- 24	236 +- 24	930 +- 50
I00G	216 +- 22	257 +- 26	243 +- 24	238 +- 24	950 +- 50
I00H	225 +- 23	264 +- 26	241 +- 24	240 +- 24	970 +- 50
I00I	230 +- 23	270 +- 27	244 +- 24	245 +- 24	990 +- 50
I00J	205 +- 21	257 +- 26	239 +- 24	235 +- 23	940 +- 50
I00K	207 +- 21	246 +- 25	228 +- 23	228 +- 23	910 +- 50
I00L	199 +- 20	247 +- 25	233 +- 23	233 +- 23	910 +- 50
I03A	163 +- 16	207 +- 21	195 +- 19	193 +- 19	760 +- 40
I03B	168 +- 17	212 +- 21	190 +- 19	204 +- 20	770 +- 40
I03C	149 +- 15	196 +- 20	179 +- 18	192 +- 19	720 +- 40
I03D	227 +- 23	287 +- 29	262 +- 26	296 +- 30	1070 +- 50
I03E	329 +- 33	379 +- 38	358 +- 36	359 +- 36	1420 +- 70
I03F	189 +- 19	245 +- 24	216 +- 22	216 +- 22	870 +- 40
I03G	170 +- 17	201 +- 20	186 +- 19	178 +- 18	740 +- 40
I03H	152 +- 15	228 +- 23	213 +- 21	208 +- 21	800 +- 40
I03I	177 +- 18	213 +- 21	190 +- 19	188 +- 19	770 +- 40

Table 4.06 (Cont'd)
TLD, Environmental
(μGy ± 10%)

Location	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total
103J	171 +- 17	221 +- 22	212 +- 21	205 +- 20	810 +- 40
103K	175 +- 17	225 +- 22	202 +- 20	201 +- 20	800 +- 40
103L	171 +- 17	210 +- 21	183 +- 18	192 +- 19	760 +- 40
175	185 +- 18	326 +- 33	209 +- 21	210 +- 21	930 +- 50
186	145 +- 14	182 +- 18	160 +- 16	157 +- 16	640 +- 30
187	138 +- 14	193 +- 19	170 +- 17	169 +- 17	670 +- 30
188	158 +- 16	196 +- 20	173 +- 17	169 +- 17	700 +- 30
189	154 +- 15	198 +- 20	192 +- 19	179 +- 18	720 +- 40
190	116 +- 12	160 +- 16	136 +- 14	136 +- 14	550 +- 30
191	134 +- 13	190 +- 19	165 +- 16	168 +- 17	660 +- 30
192	131 +- 13	175 +- 18	147 +- 15	169 +- 17	620 +- 30
193	127 +- 13	174 +- 17	136 +- 14	153 +- 15	590 +- 30
194	156 +- 16	215 +- 22	181 +- 18	188 +- 19	740 +- 40
195	122 +- 12	175 +- 18	148 +- 15	154 +- 15	600 +- 30
196	117 +- 12	165 +- 17	138 +- 14	149 +- 15	570 +- 30
197	130 +- 13	195 +- 19	164 +- 16	173 +- 17	660 +- 30
198	140 +- 14	193 +- 19	152 +- 15	169 +- 17	650 +- 30
199	163 +- 16	217 +- 22	178 +- 18	194 +- 19	750 +- 40
J00	158 +- 16	203 +- 20	162 +- 16	180 +- 18	700 +- 40
J20	161 +- 16	201 +- 20	165 +- 16	189 +- 19	720 +- 40
J35	169 +- 17	202 +- 20	183 +- 18	185 +- 18	740 +- 40
J70	236 +- 24	259 +- 26	275 +- 27	334 +- 33	1100 +- 60
K01	157 +- 16	220 +- 22	176 +- 18	200 +- 20	750 +- 40
K02	174 +- 17	221 +- 22	188 +- 19	201 +- 20	790 +- 40
L01	135 +- 13	193 +- 19	160 +- 16	169 +- 17	660 +- 30
L02	201 +- 20	253 +- 25	212 +- 21	224 +- 22	890 +- 40
L03	141 +- 14	174 +- 17	143 +- 14	150 +- 15	610 +- 30
L04	173 +- 17	190 +- 19	169 +- 17	186 +- 19	720 +- 40
M02	219 +- 22	273 +- 27	244 +- 24	268 +- 27	1000 +- 50
N01	148 +- 15	169 +- 17	153 +- 15	167 +- 17	640 +- 30
P01	99 +- 10	142 +- 14	107 +- 11	107 +- 11	450 +- 20
P03	121 +- 12	174 +- 17	124 +- 12	137 +- 14	560 +- 30

NA : Data not Available - Lost or destroyed TLD, or site not in use for this collection interval.

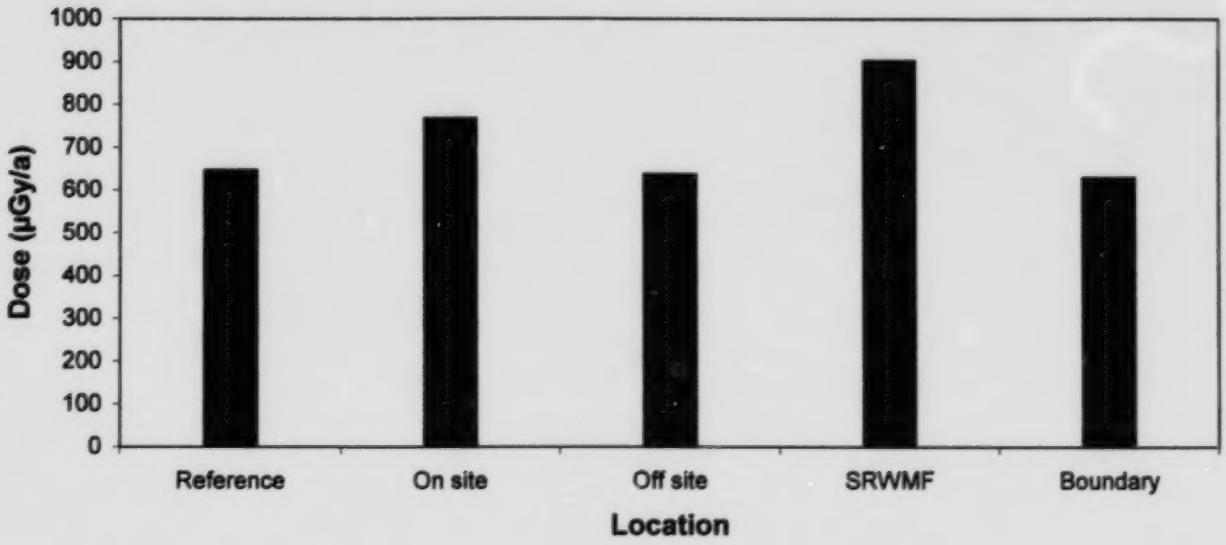


Figure 4.05
TLD Results

4.6 Airborne Radiostrontiums (GEM)

Since Sr-89,90 releases are so low, the expected concentration in environmental samples is well below the detection limit.

PLGS gaseous emissions are continuously monitored at their source by the Gaseous Effluent Monitor (GEM). The filters are changed daily and the weekly composite is sent to the lab for analyses. Fifty two sets of these filters were analysed for Sr-89,90. If the release rate warrants it, or if significant beta activity is detected in environmental air samples, a Sr-89,90 analysis is performed on those samples.

Strontium-90 was detected on one set of these GEM filters at a level close to the detection limit. This translated into 2E+3 Bq released in 1998, compared with an annual DEL of 1.2E+13 Bq. No further analyses were indicated.

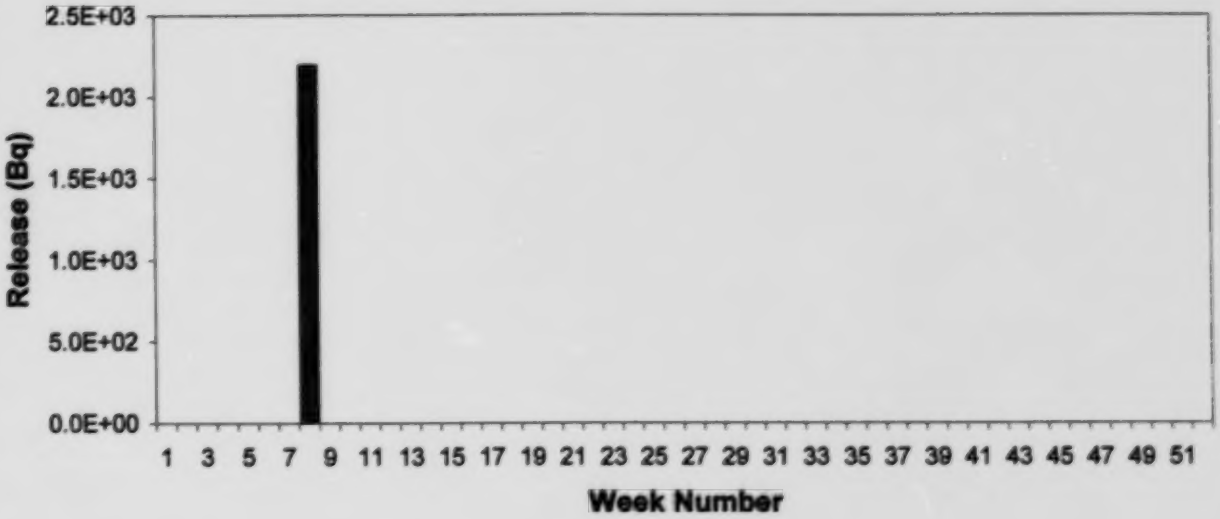


Figure 4.06
Sr-90 Releases (Measured at Source)

4.7 Milk

There were no detected radionuclides in milk attributed to PLGS operations.

Milk from a commercial dairy is purchased each month from a supermarket in Fredericton. Additional milk from herds in the South of the province are analysed where possible. All samples are analysed for gamma emitting radionuclides and tritium. There are no commercial herds or individual cows producing milk in the Point Lepreau area. The closest herds to PLGS are in Oak Bay (60 km distant), Central Blissville (70 km distant), and Hammond River (60 km distant), and the milk from these locations is analysed quarterly or as available.

Table 4.07 is a summary of the detected radionuclides in milk. Cesium-137 was detected in four of the 22 samples collected, at an average concentration of 0.07 Bq/L. The Cs-137 originated from fallout from bomb tests and the Chernobyl accident. Naturally occurring radionuclides (including K-40 at about 50 Bq/L and, occasionally, progeny of uranium and thorium) are also detected in milk. As airborne emissions from PLGS are monitored continuously, and were insignificant all year, neither tritium nor gamma emitting radionuclides attributable to the operation of PLGS would be expected to be detected in these milk samples.

Table 4.07
Milk
(Bq/L)

Analysis Type (Total Number)	Critical Level Mean (Range)	Indicator Stations Mean (F) (Range)	Highest Indicator Station Location	Mean (F) (Range)	Reference Station Mean (F) (Range)
Be-7 (22)	3.4E-01 (2.6E-01 - 4.0E-01)	*		*	3.8E-01 (1/11) (3.8E-01 - 3.8E-01)
Cs-137 (22)	4.9E-02 (3.8E-02 - 5.6E-02)	8.3E-02 (3/11) (6.8E-02 - 9.9E-02)	A11	9.1E-02 (2/5) (8.3E-02 - 9.9E-02)	7.1E-02 (1/11) (7.1E-02 - 7.1E-02)
K-40 (22)	1.0E+00 (1.4E-01 - 3.5E+00)	5.1E+01 (11/11) (4.7E+01 - 5.6E+01)	X10	5.5E+01 (2/2) (5.4E+01 - 5.6E+01)	5.2E+01 (11/11) (5.0E+01 - 5.3E+01)

* : The activity is less than or equal to the Critical Level (99% Confidence Level).

F : Number of analyses greater than the Critical Level/Total number of analyses.

4.8 Well Water

No gamma emitting radionuclides other than those occurring in nature from radon progeny were detected. The beta activity is due to the presence of naturally occurring radionuclides peculiar to certain locations. The H-3 in five of the 20 samples is most likely due to surface runoff into shallow wells. The source of this H-3 is PLGS emissions.

Table 4.08
Well Water
(Bq/L)

Analysis Type (Total Number)	Critical Level Mean (Range)	Indicator Stations Mean (F) (Range)	Highest Indicator Station Location	Mean (F) (Range)	Reference Station Mean (F) (Range)
ALPHA (22)	6.2E-02 (2.5E-02 - 1.6E-01)	1.5E-01 (13/20) (3.3E-02 - 3.3E-01)	N01	3.0E-01 (2/2) (2.6E-01 - 3.3E-01)	8.6E-02 (2/2) (7.6E-02 - 9.6E-02)
BETA (22)	4.2E-02 (2.5E-02 - 1.1E-01)	1.3E-01 (17/20) (4.4E-02 - 3.9E-01)	F01	2.4E-01 (2/2) (8.4E-02 - 3.9E-01)	7.6E-02 (2/2) (6.2E-02 - 9.0E-02)
H-3 (22)	1.2E+01 (1.1E+01 - 1.3E+01)	2.2E+01 (5/20) (1.4E+01 - 4.0E+01)	H04	4.0E+01 (1/2) (4.0E+01 - 4.0E+01)	*

* : The activity is less than or equal to the Critical Level (99% Confidence Level).

F : Number of analyses greater than the Critical Level/Total number of analyses.

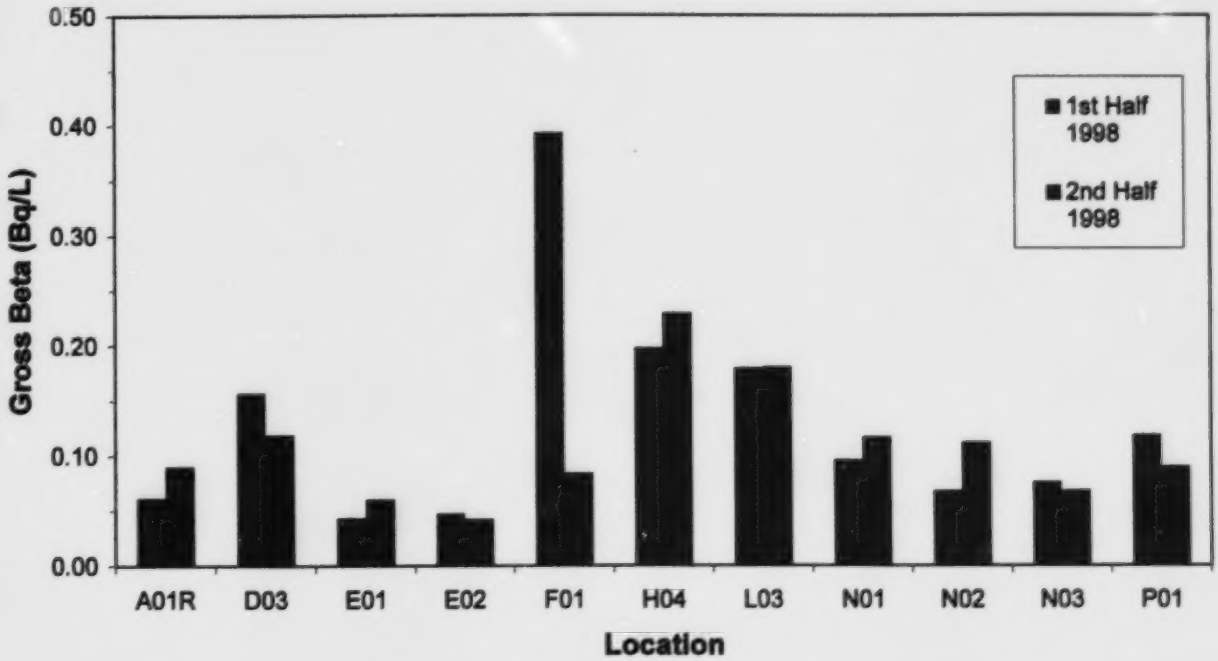


Figure 4.07 Gross Beta in Well Water

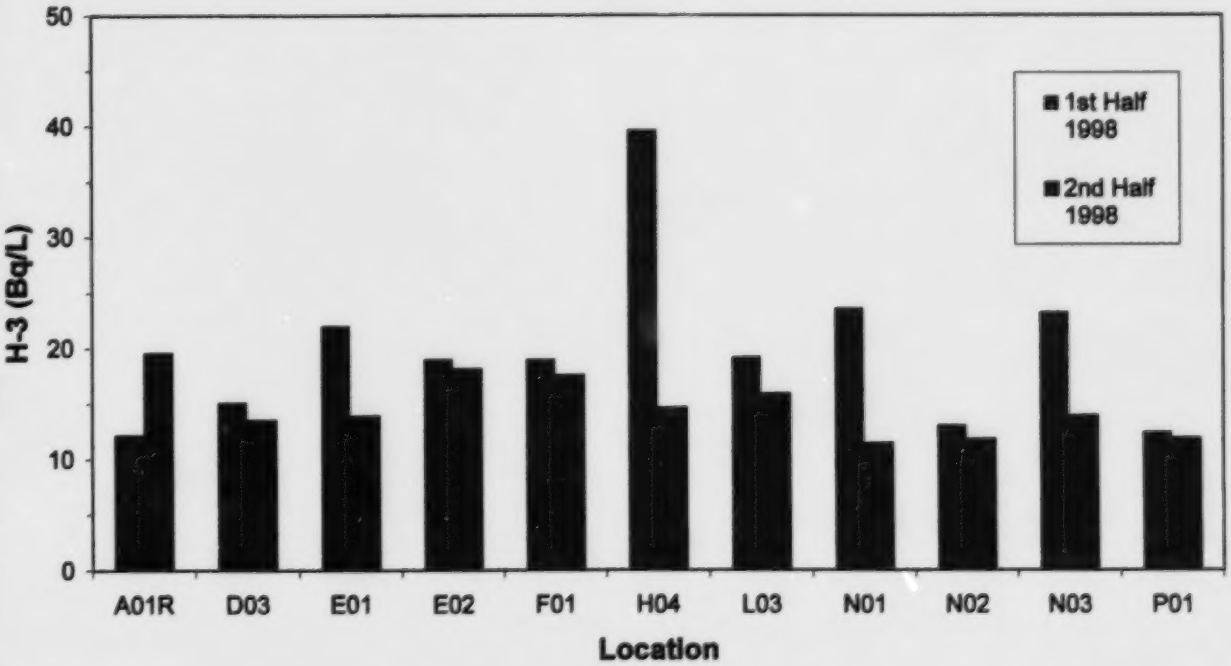


Figure 4.08 Tritium in Well Water

Water is collected semi-annually from the 11 wells shown in Figure 3.03. Two of these wells are onsite.

Figures 4.07 and 4.08 show the gross beta and H-3 results for each sample. "Less Than" values were plotted for non-detected results. The H-3 measurements were made after samples had been allowed to sit for up to two weeks to avoid radioactive interference from the relatively abundant, but short half-life, radon progeny which are common in most well waters. Tritium originates in the washout into precipitation and subsequent drainage into some of the wells. Rainwater analyses indicate H-3 concentrations ranging from 15 to 420 Bq/L in 31 of 36 samples.

The 1996 Guidelines for Canadian Drinking Water Quality recommend 7 000 Bq/L as the maximum acceptable concentration for H-3 in drinking water. The highest average well water H-3 content was less than one percent of the recommended maximum concentration.

4.9 Other Water

Tritium, from PLGS emissions, was detected in eight of the 14 samples.

This is a new category which includes ponds, lakes, streams, and runoff samples. In the past, these were informally collected and analysed under the miscellaneous category, due to the high variability and low usefulness of the data. Most of these samples are from onsite locations.

Detected H-3 activity ranged from 32 to 200 Bq/L. Variability can be due to the size of the reservoir and the residence time at the location. Figure 4.09 shows each sample (location codes are given in Appendix C). "Less Than" values were plotted for non-detected results.

Table 4.09
Pond/Puddle/Surface Water
(Bq/L)

Analysis Type (Total Number)	Critical Level Mean (Range)	Indicator Stations Mean (F) (Range)	Highest Indicator Station Location	Highest Indicator Station Mean (F) (Range)	Reference Station Mean (F) (Range)
H-3 (14)	1.2E+01 (1.2E+01 - 1.3E+01)	9.2E+01 (8/14) (3.2E+01 - 2.0E+02)	PLGS	2.0E+02 (1/1) (2.0E+02 - 2.0E+02)	*

* : The activity is less than or equal to the Critical Level (99% Confidence Level).
F : Number of analyses greater than the Critical Level/Total number of analyses.

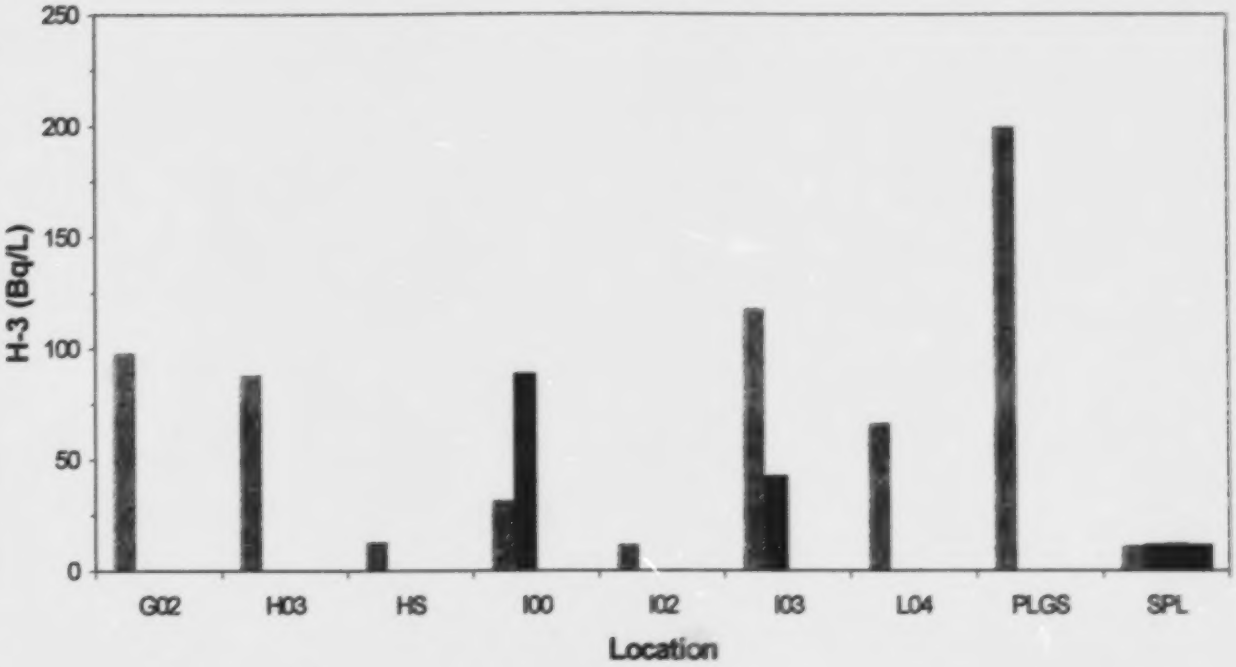


Figure 4.09
Tritium in Surface Water

4.10 Berries

No radionuclides attributable to PLGS emissions were detected in these 12 samples.

This is a new category for 1998. In the past, these were informally collected and analysed under the miscellaneous category. Most of these samples were blueberries from the commercial fields at Pennfield. Some local residents provided other species from the Lepreau Peninsula.

The detected Cs-137 levels, typical for Eastern North America, are from bomb tests and Chernobyl.

Table 4.10
Berry, Various
(Bq/kg)

Analysis Type (Total Number)	Critical Level Mean (Range)	Indicator Stations Mean (F) (Range)	Highest Indicator Station Location	Mean (F) (Range)	Reference Station Mean (F) (Range)
Cs-137 (12)	2.0E+00 (5.1E-01 - 6.2E+00)	1.5E+00 (2/11) (6.8E-01 - 2.3E+00)	I03	2.3E+00 (1/1) (2.3E+00 - 2.3E+00)	*
K-40 (12)	2.1E+01 (3.4E+00 - 6.2E+01)	7.3E+01 (9/11) (2.3E+01 - 2.3E+02)	G02	1.6E+02 (2/2) (9.4E+01 - 2.3E+02)	*

* : The activity is less than or equal to the Critical Level (99% Confidence Level).

F : Number of analyses greater than the Critical Level/Total number of analyses.

4.11 Garden Vegetables

No radionuclides attributable to PLGS emissions were detected in these 29 samples.

This is a new category for 1998. In the past, these were informally collected and analysed under the miscellaneous category. Most samples were taken from a local garden in Dipper Harbour (4 km away from PLGS in the predominant wind direction).

Table 4.11
Garden Vegetables
(Bq/kg)

Analysis Type (Total Number)	Critical Level Mean (Range)	Indicator Stations Mean (F) (Range)	Highest Indicator Station Location	Mean (F) (Range)	Reference Station Mean (F) (Range)
K-40 (29)	3.3E+01 (5.2E+00 - 1.3E+02)	1.3E+02 (29/29) (4.7E+01 - 2.9E+02)	N01	1.3E+02 (29/29) (4.7E+01 - 2.9E+02)	*

* : The activity is less than or equal to the Critical Level (99% Confidence Level).

F : Number of analyses greater than the Critical Level/Total number of analyses.

4.12 Vegetation (Lichen)

No radionuclides from PLGS were detected in these 18 samples.

Different species of lichen and moss concentrate a wide range of radionuclides, both natural (Be-7 and K-40) and man-made (Cs-137), and are sensitive indicators of radionuclides in the environment. These samples are collected whenever and wherever available from onsite locations.

Cesium-137 was detected (in 2 of 14 samples) at levels typical for Eastern North America. These are lower than in past years.

Table 4.12
Vegetation
(Bq/kg)

Analysis Type (Total Number)	Critical Level Mean (Range)	Indicator Stations Mean (F) (Range)	Highest Indicator Station Location	Mean (F) (Range)	Reference Station Mean (F) (Range)
Be-7 (18)	9.4E+01 (1.8E+01 - 2.3E+02)	2.7E+02 (9/18) (1.5E+02 - 4.1E+02)	I00	3.8E+02 (3/4) (3.5E+02 - 4.1E+02)	*
Cs-137 (18)	1.3E+01 (4.3E+00 - 1.9E+01)	2.0E+01 (2/18) (1.6E+01 - 2.4E+01)	L01	2.4E+01 (1/1) (2.4E+01 - 2.4E+01)	*
K-40 (18)	2.2E+02 (6.3E+01 - 3.4E+02)	2.2E+02 (4/18) (1.5E+02 - 2.8E+02)	G02	2.8E+02 (1/4) (2.8E+02 - 2.8E+02)	*

* : The activity is less than or equal to the Critical Level (99% Confidence Level).

F : Number of analyses greater than the Critical Level/Total number of analyses.

4.13 Soil

In 1998, there were no detectable radionuclides that could be attributed to the operation of PLGS in any of the ten samples analysed.

Soil samples are taken from a variety of onsite locations throughout most of the year.

Most samples contained K-40 (210 to 860 Bq/kg), Be-7 (32 to 160 Bq/kg) and Ac-228 (10 to 730 Bq/kg). Seven contained Cs-137 (5.5 to 57 Bq/kg) at typical levels for the region. See Table 4.13. Figure 4.10 shows individual Cs-137 results which seem to be a function of the organic load in the sample. "Critical Levels" were plotted for non-detected results. Location codes are shown in Appendix C.

Table 4.13
Soil (Bq/kg)

Analysis Type (Total Number)	Critical Level Mean (Range)	Indicator Stations Mean (F) (Range)	Highest Indicator Station Location	Mean (F) (Range)	Reference Station Mean (F) (Range)
Be-7 (10)	2.2E+01 (7.0E+00 - 6.3E+01)	7.4E+01 (4/10) (3.2E+01 - 1.6E+02)	I89	1.6E+02 (1/1) (1.6E+02 - 1.6E+02)	*
Cs-137 (10)	2.8E+00 (6.4E-01 - 7.9E+00)	3.0E+01 (7/10) (5.5E+00 - 5.7E+01)	F01	5.7E+01 (1/1) (5.7E+01 - 5.7E+01)	*
Ac-228 (10)	9.0E+00 (2.2E+00 - 2.9E+01)	2.0E+02 (6/10) (1.0E+01 - 7.3E+02)	I11	4.1E+02 (2/2) (8.7E+01 - 7.3E+02)	*
K-40 (10)	7.2E+01 (1.2E+01 - 1.3E+02)	5.4E+02 (9/10) (2.1E+02 - 8.6E+02)	I89	8.1E+02 (1/1) (8.1E+02 - 8.1E+02)	*

* : The activity is less than or equal to the Critical Level (99% Confidence Level).

F : Number of analyses greater than the Critical Level/Total number of analyses.

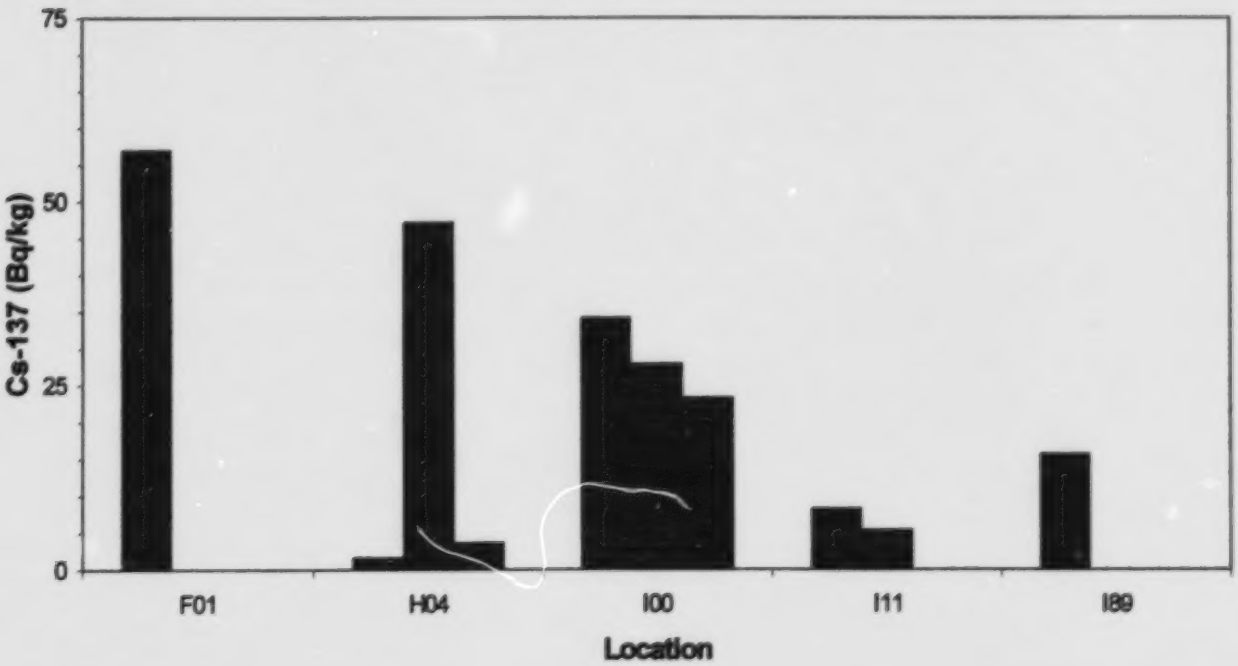


Figure 4.10
Cs-137 in Soil

4.14 Precipitation

Tritium from PLGS was detected in 31 of 36 onsite samples.

This is a new category of sample that was informally collected and analysed under the miscellaneous category in previous years. Rainwater is continuously collected at the four onsite air monitoring stations (shown in Figure 3.02). The samples are changed at least monthly, depending on rainfall and freeze up.

Detected H-3 levels spanned 15 to 420 Bq/L, depending on the amount of rainfall. Results are given in Table 4.14 and shown in Figure 4.11. "Critical Levels" are plotted for non-detected results.

Table 4.14
Rain Water
(Bq/L)

Analysis Type (Total Number)	Critical Level Mean (Range)	Indicator Stations Mean (F) (Range)	Highest Indicator Station Location	Mean (F) (Range)	Reference Station Mean (F) (Range)
H-3 (36)	1.2E+01 (1.1E+01 - 1.3E+01)	1.1E+02 (31/36) (1.5E+01 - 4.2E+02)	H04	1.4E+02 (8/9) (5.0E+01 - 4.0E+02)	*
Be-7 (36)	3.1E+00 (1.6E+00 - 5.0E+00)	4.7E+00 (1/36) (4.7E+00 - 4.7E+00)	H04	4.7E+00 (1/9) (4.7E+00 - 4.7E+00)	*

* : The activity is less than or equal to the Critical Level (99% Confidence Level).

F : Number of analyses greater than the Critical Level/Total number of analyses.

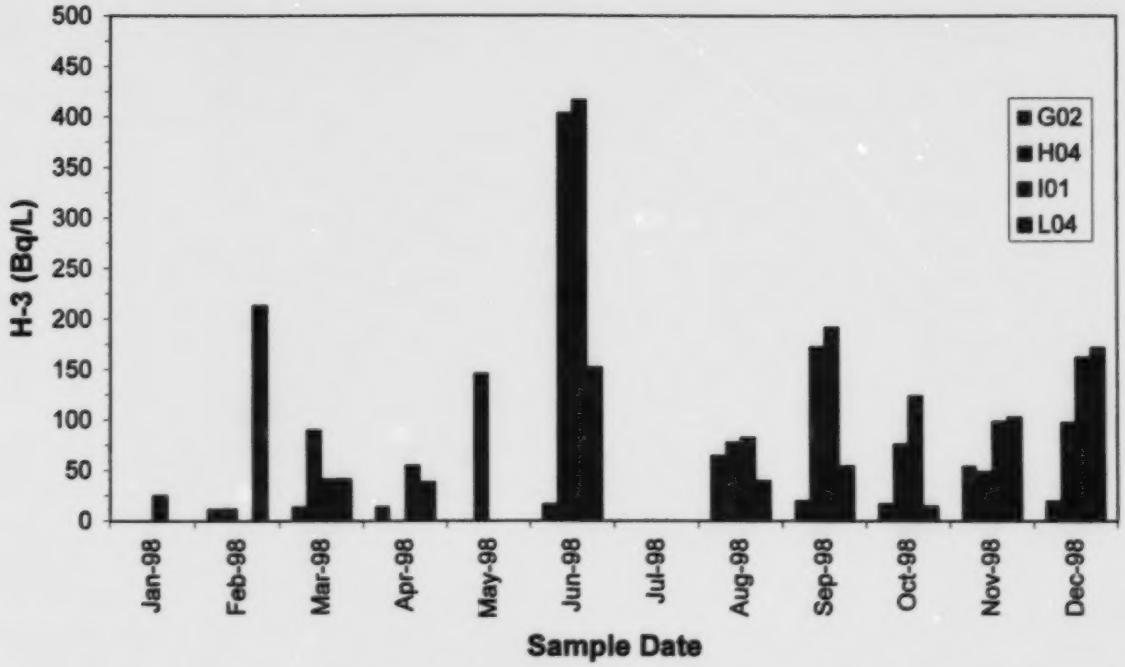


Figure 4.11 Tritium in Precipitation

4.15 Sea Water

Naturally occurring K-40 was the only gamma emitting radionuclide found in sea water during the sampling period. Tritium from PLGS was detected in 8 of 23 indicator station samples.

Seawater is collected quarterly from three locations close to PLGS and one reference location near Saint John. There are at least four samples for each of the locations except G01, which is not a routine site.

The Critical Level for H-3 in sea water averages about 12 Bq/L. Calculations suggest that the long term average concentration of tritium in sea water due to releases from PLGS in the liquid effluent pathway was about 70 Bq/L at the out-fall (samples are not usually collected at this point, but are taken at the shoreline nearby). This calculation takes into account the total tritium released over the year, the flow rate of the condenser cooling water (about 24 m3/s), and tidal mixing. A dilution factor of 20 is assumed for tidal mixing at the out-fall during normal coolant flows. For collection further away, a tidal mixing factor of about 40 or even higher, is more realistic. A factor of 40 would result in an average of about 30 Bq/L of sea water in 1998 at the H03 location (average of the detected values is 20 Bq/L). Table 4.15 is a summary of the detected radionuclides. Figure 4.12 shows the H-3 results for each location. Each bar represents the detected H-3 level (or the "Critical

Level") for each sample. Appendix C lists the location codes.

Table 4.15
Sea Water
(Bq/L)

Analysis Type (Total Number)	Critical Level Mean (Range)	Indicator Stations Mean (F) (Range)	Highest Indicator Station Location	Mean (F) (Range)	Reference Station Mean (F) (Range)
H-3 (28)	1.2E+01 (1.1E+01 - 1.5E+01)	2.1E+01 (8/23) (1.4E+01 - 4.8E+01)	H03	2.3E+01 (6/10) (1.5E+01 - 4.8E+01)	*
K-40 (28)	3.8E+00 (8.6E-01 - 6.4E+00)	1.1E+01 (22/23) (5.9E+00 - 1.5E+01)	E03	1.2E+01 (5/6) (1.1E+01 - 1.3E+01)	1.2E+01 (3/5) (1.1E+01 - 1.4E+01)

* : The activity is less than or equal to the Critical Level (99% Confidence Level).

F : Number of analyses greater than the Critical Level/Total number of analyses.

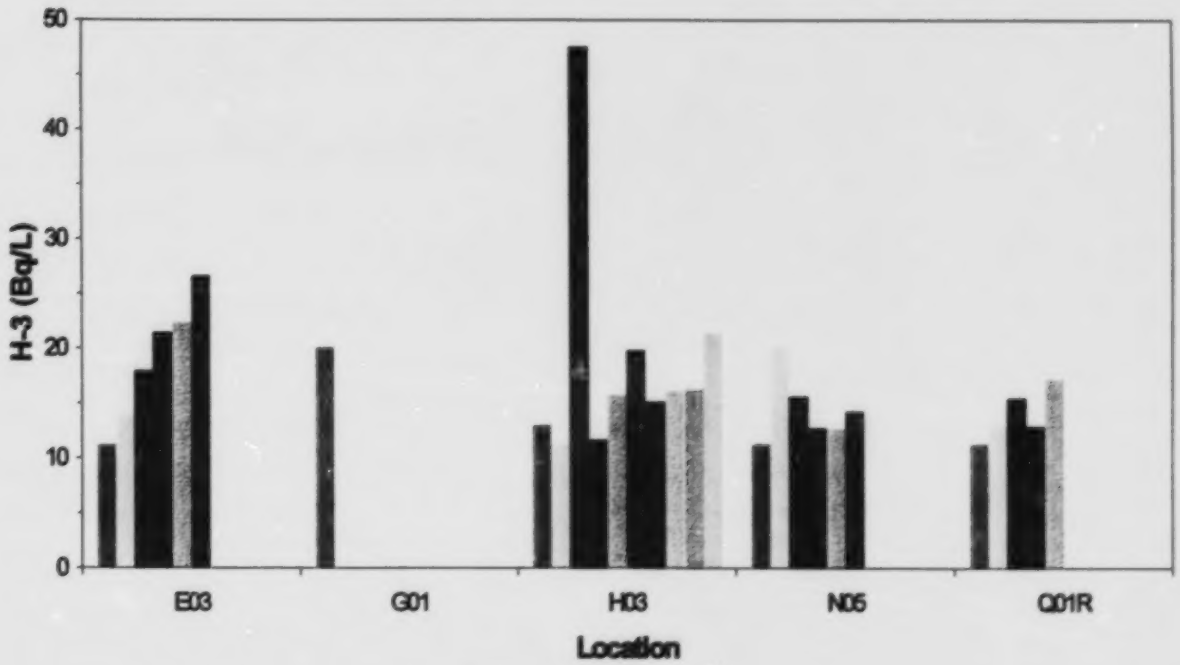


Figure 4.12
Tritium in Seawater

4.16 Clams

Most of the seafood analysed in the environmental program contain detectable levels of K-40. Clams may also contain detectable quantities of Ac-228. No contribution of gamma emitting radionuclides from the operation of Point Lepreau was detected in 1998.

The nature of the fishery has changed over the last few years. The inshore fishery often faces restrictions placed upon the harvesting of shellfish, either for conservation of stocks or because of bacterial contamination, algal blooms, or other natural cycles. This restricts the availability of some sample types for analysis.

Table 4.16
Clams
Edible, Raw Mass (Bq/kg)

Analysis Type (Total Number)	Critical Level Mean (Range)	Indicator Stations Mean (F) (Range)	Highest Indicator Station Location	Mean (F) (Range)	Reference Station Mean (F) (Range)
K-40 (6)	4.7E+01 (2.5E+01 - 1.3E+02)	1.6E+02 (5/6) (8.5E+01 - 2.4E+02)	C01	2.1E+02 (2/3) (1.9E+02 - 2.4E+02)	*

* : The activity is less than or equal to the Critical Level (99% Confidence Level).

F : Number of analyses greater than the Critical Level/Total number of analyses.

4.17 Fish

Most of the seafood analysed in the environmental program contain detectable levels of K-40. No contribution of gamma emitting radionuclides from the operation of Point Lepreau was detected in 1998.

The nature of the fishery has changed over the last few years. Herring and mackerel, which used to make up the bulk of the analyses, are now less available for analysis. The fish category now tends to be made up of dogfish, cod, hake and sardines, if they are available at all.

Table 4.17
Fish, Various
Edible, Raw Mass (Bq/kg)

Analysis Type (Total Number)	Critical Level Mean (Range)	Indicator Stations Mean (F) (Range)	Highest Indicator Station Location	Mean (F) (Range)	Reference Station Mean (F) (Range)
K-40 (3)	2.1E+01 (1.0E+01 - 3.2E+01)	1.0E+02 (3/3) (7.7E+01 - 1.2E+02)	G04	1.2E+02 (1/1) (1.2E+02 - 1.2E+02)	*

* : The activity is less than or equal to the Critical Level (99% Confidence Level).

F : Number of analyses greater than the Critical Level/Total number of analyses.

4.18 Lobster

Most of the seafood analysed in the environmental program contain detectable levels of K-40. No contribution of gamma emitting radionuclides from the operation of Point Lepreau was detected in 1998, even though several of the samples were collected close to the cooling water outflow from PLGS.

Table 4.18
Lobster
Edible, Cooked Mass (Bq/kg)

Analysis Type (Total Number)	Critical Level Mean (Range)	Indicator Stations Mean (F) (Range)	Highest Indicator Station Location	Mean (F) (Range)	Reference Station Mean (F) (Range)
K-40 (8)	4.9E+01 (1.5E+01 - 7.1E+01)	1.1E+02 (7/8) (9.0E+01 - 1.2E+02)	H02	1.1E+02 (7/8) (9.0E+01 - 1.2E+02)	*

* : The activity is less than or equal to the Critical Level (99% Confidence Level).

F : Number of analyses greater than the Critical Level/Total number of analyses.

4.19 Periwinkles

Most of the seafood analysed in the environmental program contain detectable levels of K-40. No contribution of gamma emitting radionuclides from the operation of Point Lepreau was detected in 1998.

Table 4.19
Periwinkles
Edible, Raw Mass (Bq/kg)

Analysis Type (Total Number)	Critical Level Mean (Range)	Indicator Stations Mean (F) (Range)	Highest Indicator Station Location	Mean (F) (Range)	Reference Station Mean (F) (Range)
K-40 (14)	5.1E+01 (1.7E+01 - 1.1E+02)	1.3E+02 (12/14) (5.5E+01 - 1.7E+02)	E03	1.3E+02 (3/3) (1.0E+02 - 1.5E+02)	*

* : The activity is less than or equal to the Critical Level (99% Confidence Level).

F : Number of analyses greater than the Critical Level/Total number of analyses.

4.20 Aquaculture Salmon

The aquaculture salmon industry is important to the area to the west of PLGS. Potassium-40 is detected in these samples, but due to their distance from PLGS, that is all that would be expected.

Table 4.20
Atlantic Salmon
Raw Mass (Bq/kg)

Analysis Type (Total Number)	Critical Level Mean (Range)	Indicator Stations Mean (F) (Range)	Highest Indicator Station Location	Mean (F) (Range)	Reference Station Mean (F) (Range)
K-40 (3)	2.6E+01 (4.8E+00 - 4.0E+01)	1.7E+02 (3/3) (1.6E+02 - 1.7E+02)	A07	1.7E+02 (1/1) (1.7E+02 - 1.7E+02)	*

* : The activity is less than or equal to the Critical Level (99% Confidence Level).

F : Number of analyses greater than the Critical Level/Total number of analyses.

4.21 Scallops

Most of the seafood analysed in the environmental program contain detectable levels of K-40. Scallops may also contain detectable quantities of Ac-228. No contribution of gamma emitting radionuclides from the operation of Point Lepreau was detected in 1998.

The inshore fishery often faces restrictions or total bans placed upon the harvesting of scallops for conservation of stocks. This affects the number of samples available for analysis.

Table 4.21
Scallops
Edible, Raw Mass (Bq/kg)

Analysis Type (Total Number)	Critical Level Mean (Range)	Indicator Stations Mean (F) (Range)	Highest Indicator Station Location	Highest Indicator Station Mean (F) (Range)	Reference Station Mean (F) (Range)
K-40 (2)	2.5E+01 (6.8E+00 - 4.3E+01)	1.0E+02 (2/2) (7.0E+01 - 1.4E+02)	E03	1.0E+02 (2/2) (7.0E+01 - 1.4E+02)	*

* : The activity is less than or equal to the Critical Level (99% Confidence Level).

F : Number of analyses greater than the Critical Level/Total number of analyses.

4.22 Dulse

Most of the seafood analysed in the environmental program contain detectable levels of K-40. No contribution of gamma emitting radionuclides from the operation of Point Lepreau was detected in 1998.
See Table 4.22.

Dulse is an edible seaweed that is a popular snack food in the area. Fifteen samples were collected in 1998.

Table 4.22
Dulse
Wet Mass (Bq/kg)

Analysis Type (Total Number)	Critical Level Mean (Range)	Indicator Stations Mean (F) (Range)	Highest Indicator Station Location	Highest Indicator Station Mean (F) (Range)	Reference Station Mean (F) (Range)
K-40 (15)	9.3E+01 (2.7E+00 - 1.8E+02)	3.9E+02 (15/15) (2.1E+02 - 9.4E+02)	N05	4.8E+02 (5/5) (2.7E+02 - 9.4E+02)	*

* : The activity is less than or equal to the Critical Level (99% Confidence Level).

F : Number of analyses greater than the Critical Level/Total number of analyses.

4.23 Other Sea Plants

All of the seafood analysed in the environmental program contain K-40. No contribution of gamma emitting radionuclides from the operation of Point Lepreau was detected in 1998. See Table 4.23.

Sea plants other than dulse are analysed. Various species of seaweed (for example, *Ascophylum*) occur on the rocks on the Point Lepreau peninsula and are collected from time to time. One of the 19 samples collected contained Be-7, a cosmogenic radionuclide. All contained naturally occurring K-40 at an average of 240 Bq/kg.

Table 4.23
Sea Plant
Wet Mass (Bq/kg)

Analysis Type (Total Number)	Critical Level Mean (Range)	Indicator Stations Mean (F) (Range)	Highest Indicator Station Location	Mean (F) (Range)	Reference Station Mean (F) (Range)
Be-7 (19)	7.8E+00 (4.1E+00 - 1.2E+01)	4.8E+00 (1/19) (4.8E+00 - 4.8E+00)	H03	4.8E+00 (1/11) (4.8E+00 - 4.8E+00)	*
K-40 (19)	4.0E+01 (2.7E+00 - 7.5E+01)	2.4E+02 (19/19) (1.8E+02 - 3.3E+02)	G01	3.3E+02 (1/1) (3.3E+02 - 3.3E+02)	*

* : The activity is less than or equal to the Critical Level (99% Confidence Level).

F : Number of analyses greater than the Critical Level/Total number of analyses.

4.24 Sediment

No contribution of gamma emitting radionuclides from the operation of Point Lepreau was detected in 1998.

Sediments are collected quarterly from ten locations. See Table 4.24. Figure 4.13 shows the Cs-137 concentration for each location. "Critical Levels" are plotted for non-detected results.

All samples contain radioactivity from naturally occurring radionuclides (K-40 from the natural potassium in feldspar, a common mineral) and from the diminishing levels of Cs-137 fallout from bomb tests since the 1950s. A small additional Cs-137 component from Chernobyl was added to this reservoir in 1986. Actinium-228 (radioactive progeny of naturally occurring Th-232), and Be-7 (of cosmogenic origin) commonly occur in sediments. Finer grain sediments have a higher radioactivity content than coarse sediments.

Table 4.24
Sediment
(Bq/kg)

Analysis Type (Total Number)	Critical Level Mean (Range)	Indicator Stations Mean (F) (Range)	Highest Indicator Station Location	Mean (F) (Range)	Reference Station Mean (F) (Range)
Be-7 (40)	8.8E+00 (3.7E+00 - 1.7E+01)	4.2E+01 (20/36) (1.0E+01 - 1.3E+02)	N04	9.2E+01 (4/4) (7.4E+01 - 1.3E+02)	5.1E+01 (4/4) (3.8E+01 - 6.6E+01)
Cs-137 (40)	1.4E+00 (6.2E-01 - 3.0E+00)	4.7E+00 (7/36) (2.9E+00 - 7.3E+00)	C01	6.0E+00 (1/4) (6.0E+00 - 6.0E+00)	*
Ac-228 (40)	3.2E+00 (1.4E+00 - 7.0E+00)	2.5E+01 (22/36) (1.1E+01 - 5.6E+01)	N04	3.6E+01 (3/4) (2.5E+01 - 4.6E+01)	3.8E+01 (3/4) (3.3E+01 - 4.5E+01)
K-40 (40)	6.6E+01 (3.8E+00 - 1.3E+02)	5.6E+02 (36/36) (3.8E+02 - 8.3E+02)	N04	6.6E+02 (4/4) (5.3E+02 - 7.3E+02)	5.2E+02 (4/4) (4.4E+02 - 5.9E+02)

* : The activity is less than or equal to the Critical Level (99% Confidence Level).

F : Number of analyses greater than the Critical Level/Total number of analyses.

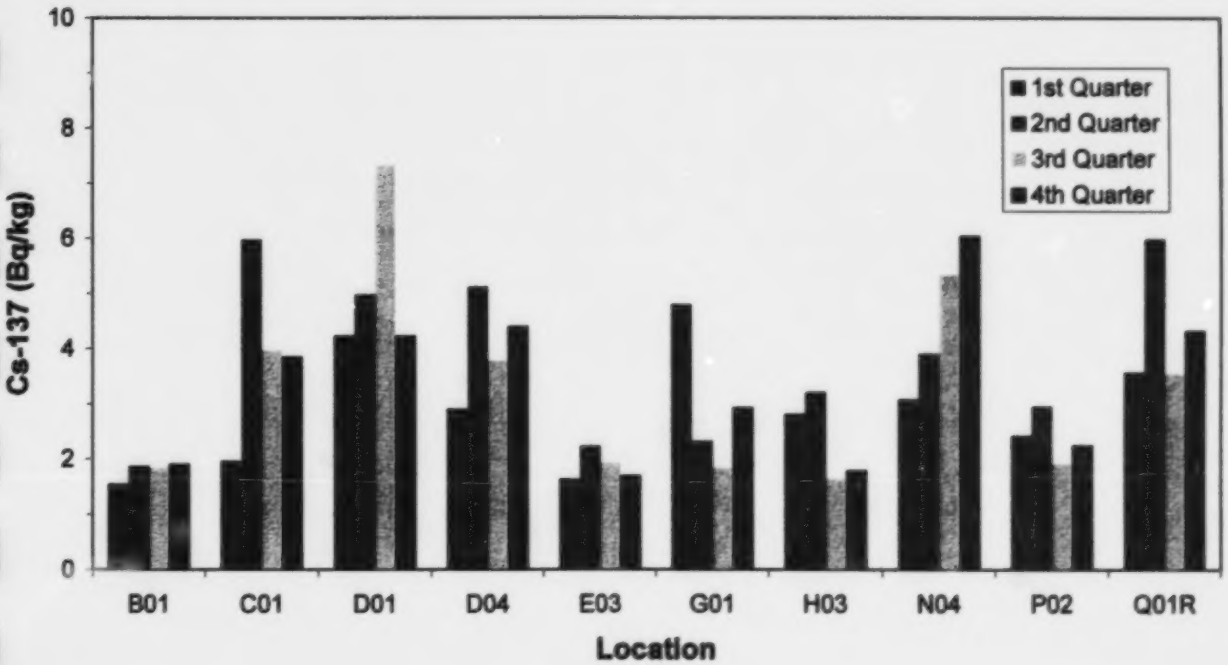


Figure 4.13
Cs-137 in Sediment

4.25 Gamma Surveys (Beaches)

Environmental gamma survey measurements are made in the inter-tidal zone on beaches in the Point Lepreau area and at the reference location 28 km to the east-north-east. Although TLDs are preferred in measuring such exposures since they span the entire year and provide integrated measurements, they cannot be used in these locations. Radiation values measured in 1998 were consistent with those measured prior to station start-up in 1982.

Table 4.25
Beach Surveys- Inter-tidal Zone
Ion Chamber (μSv/h) *

Location	Quarter 1	Quarter 2	Quarter 3	Quarter 4
B01	0.16	0.23	0.18	0.20
C01	0.13	0.23	0.16	0.14
D01	0.13	0.19	0.12	0.18
D04	0.17	0.17	0.15	0.17
E03	0.13	0.19	0.22	0.19
G01	0.21	0.24	0.22	0.19
H03	0.15	0.19	0.22	0.19
N04	0.06	0.16	0.17	0.20
P02	0.03	0.22	0.13	0.16
G01R	0.14	0.17	0.20	0.22

* : Although two decimal places are quoted, none of the determinations has this degree of precision nor of accuracy. The data are quoted to two figures just as they are estimated at each location. They should be regarded as about 0.1 to 0.2 μSv/h.

NA : Data not Available

4.26 Liquid Sr-90 (LEM)

Since Sr-89,90 releases are so low, the expected concentration in environmental samples is well below the detection limit.

PLGS liquid emissions are measured by the Liquid Effluent Monitor (LEM) before their release. A monthly composite is sent to the lab for analyses. Twelve of these composites were analysed for Sr-89,90. If the release rate warrants it, or if significant beta activity is detected in environmental well water samples, a Sr-89,90 analysis is performed on those

samples.

Strontium-90 was detected in several of these LEM samples at a level close to the detection limit. This translated into 6E+5 Bq released in 1998, compared with an annual DEL of 1.8E+14 Bq. No further analyses were indicated. See Figure 4.14.

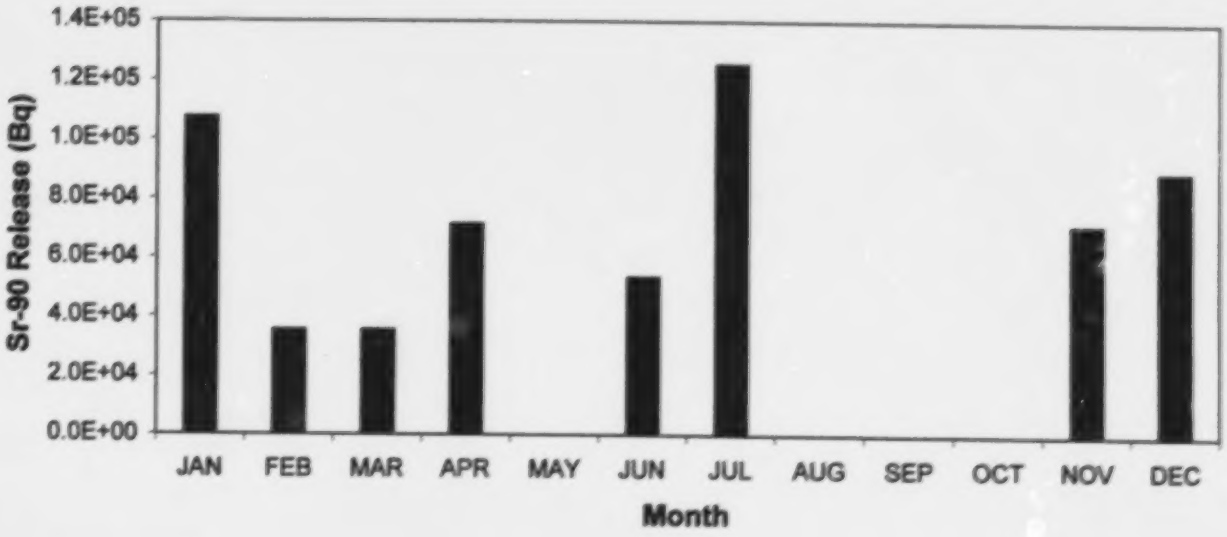


Figure 4.14
Sr-90 Releases (measured at source)

4.27 Bore Hole Water (SRWMF)

Tritium from PLGS was detected in 58 of 62 samples. No other radionuclides attributable to the operation of PLGS were detected.

Water from bore holes on the SRWMF site (Phase 1 and 2) are collected each quarter (a total of 68 samples, if all contain sufficient water to be sampled).

Tritium concentrations averaged 130 Bq/L, ranging up to 370 Bq/L. Most near-surface groundwater in the area is from rainfall which may contain up to this concentration, or more. Contamination of some of the bore holes by surface runoff is unavoidable when the bore holes are first opened because of standing-water covering the well cap. See Tables 4.26 and 4.27. Figure 4.15 shows the H-3 at each bore hole for each sample. "Critical Levels" are plotted for non-detected results.

Table 4.26
Bore Hole Water
SRWMF Phase 1 (Bq/L)

Analysis Type (Total Number)	Critical Level Mean (Range)	Indicator Stations Mean (F) (Range)	Highest Indicator Station Location	Mean (F) (Range)	Reference Station Mean (F) (Range)
H-3 (12)	1.2E+01 (1.1E+01 - 1.3E+01)	2.0E+02 (12/12) (4.7E+01 - 3.7E+02)	I00B	3.2E+02 (4/4) (2.9E+02 - 3.5E+02)	-----

F : Number of analyses greater than the Critical Level/Total number of analyses.

Table 4.27
Bore Hole Water
SRWMF Phase 2 (Bq/L)

Analysis Type (Total Number)	Critical Level Mean (Range)	Indicator Stations Mean (F) (Range)	Highest Indicator Station Location	Mean (F) (Range)	Reference Station Mean (F) (Range)
H-3 (50)	1.2E+01 (1.1E+01 - 1.7E+01)	6.6E+01 (46/50) (3.2E+01 - 1.6E+02)	I03I	1.6E+02 (1/3) (1.6E+02 - 1.6E+02)	-----

F : Number of analyses greater than the Critical Level/Total number of analyses.

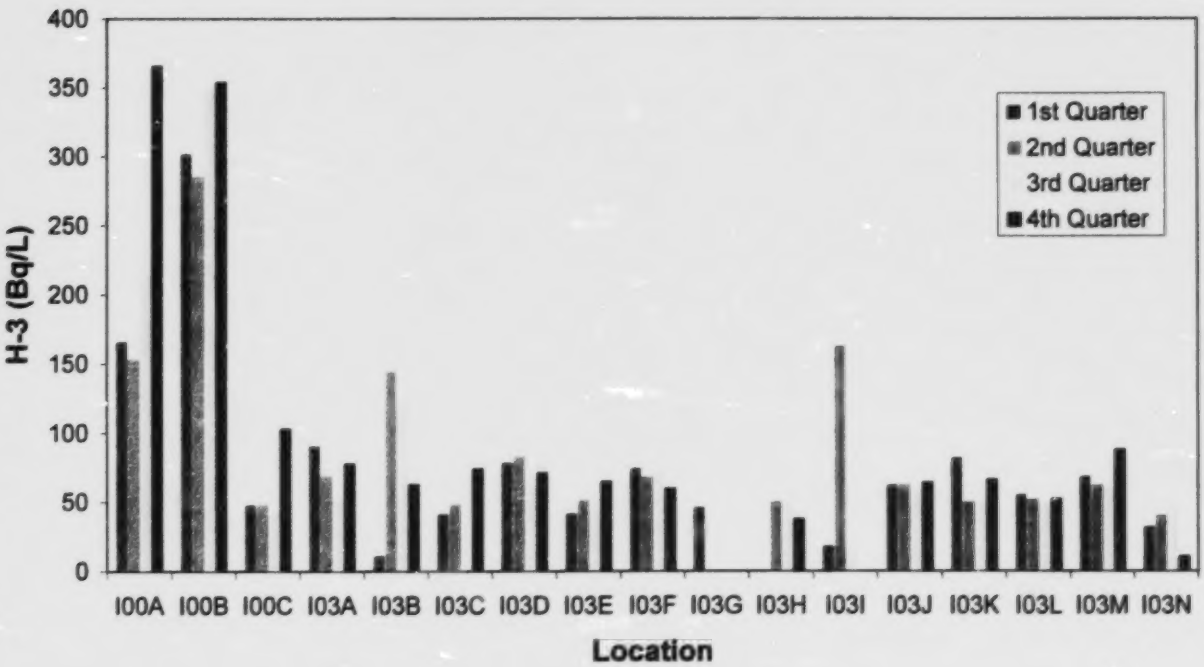


Figure 4.15
Tritium in Bore Holes

4.28 Parshall Flume (SRWMF)

Tritium from PLGS was detected in 101 of 104 samples reaching 2300 Bq/L, with a mean value of about 435 Bq/L. No other radionuclides attributable to the operation of PLGS were detected.

Rainwater at the SRWMF (Phase 1 and 2) is obtained from drainage channels (flumes) constructed to collect surface runoff from these areas. Samples are collected and analysed on a weekly basis. There is little or no flow into or out of these collection locations during the winter months and values for H-3 - the only detected radionuclide from PLGS - tend to vary little from one week to the next except after heavy rain. The values at Phase 2 are typically less than those at Phase 1, indicating possible groundwater dilution of the surface runoff to the flume. See Tables 4.28 and 4.29. Figure 4.16 compares the H-3 in the samples from the two facilities.

Table 4.28
Parshall Flume
SRWMF - Phase 1 (Bq/L)

Analysis Type (Total Number)	Critical Level Mean (Range)	Indicator Stations Mean (F) (Range)	Highest Indicator Station Location	Mean (F) (Range)	Reference Station Mean (F) (Range)
H-3 (52)	1.2E+01 (1.0E+01 - 1.4E+01)	7.6E+02 (52/52) (1.6E+02 - 2.3E+03)	101	7.6E+02 (52/52) (1.6E+02 - 2.3E+03)	-----
K-40 (52)	2.8E+00 (1.2E+00 - 6.6E+00)	2.9E+00 (1/52) (2.9E+00 - 2.9E+00)	101	2.9E+00 (1/52) (2.9E+00 - 2.9E+00)	-----

F : Number of analyses greater than the Critical Level/Total number of analyses.

Table 4.29
Parshall Flume
SRWMF - Phase 2 (Bq/L)

Analysis Type (Total Number)	Critical Level Mean (Range)	Indicator Stations Mean (F) (Range)	Highest Indicator Station Location	Mean (F) (Range)	Reference Station Mean (F) (Range)
H-3 (52)	1.2E+01 (1.0E+01 - 1.4E+01)	1.1E+02 (49/52) (1.3E+01 - 1.5E+03)	102	1.1E+02 (49/52) (1.3E+01 - 1.5E+03)	-----
K-40 (52)	2.9E+00 (1.9E+00 - 6.8E+00)	2.9E+00 (1/52) (2.9E+00 - 2.9E+00)	102	2.9E+00 (1/52) (2.9E+00 - 2.9E+00)	-----

F : Number of analyses greater than the Critical Level/Total number of analyses.

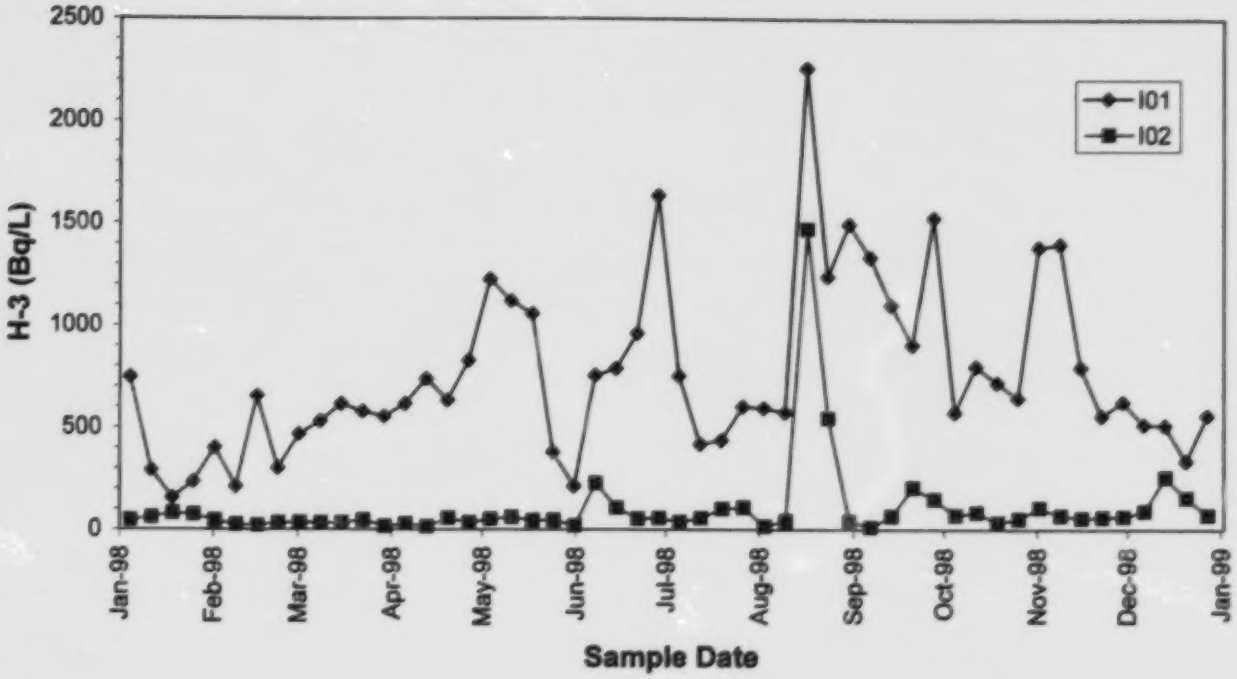


Figure 4.16
Tritium in Parshall Flumes

4.29 Drop-off TLDs (SRWMF Phase 2)

The measured radiation decreases as the distance from the SRWMF Phase 2 increases.

Dosimeters are placed in two directions from the boundary fence of Phase 2 to measure drop-off of radiation with distance from the filled dry fuel storage canisters, to about 200 metres. Results are presented in Table 4.30.

There were 72 concrete canisters filled to the end of 1998 with approximately 38 880 used-fuel bundles. Radiation drop-off measurements (Figure 4.17) with increasing distance away from the fence show distinct differences. The 'A' direction (mostly swamp after 20 m from the fence) covers drop-off to the north-east away from the perimeter fence The 'B' direction (mostly rock with some shallow sandy overburden) covers drop-off to the north-west away from the perimeter (after 75 m the TLDs are shielded from the facility by the high ground).

Table 4.30
TLD, Drop-off
(µGy +- 10%)

Location		Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total
A	5m	208 +- 21	234 +- 23	225 +- 22	218 +- 22	880 +- 40
A	10m	192 +- 19	216 +- 22	215 +- 22	220 +- 22	840 +- 40
A	15m	177 +- 18	194 +- 19	189 +- 19	196 +- 20	760 +- 40
A	20m	115 +- 11	135 +- 14	135 +- 14	127 +- 13	510 +- 30
A	25m	101 +- 10	126 +- 13	116 +- 12	112 +- 11	450 +- 20
A	50m	94 +- 9	115 +- 12	107 +- 11	101 +- 10	420 +- 20
A	75m	93 +- 9	115 +- 11	105 +- 11	100 +- 10	410 +- 20
A	100m	87 +- 9	108 +- 11	95 +- 10	95 +- 9	380 +- 20
A	118m	107 +- 11	130 +- 13	127 +- 13	122 +- 12	490 +- 20
B	5m	276 +- 28	285 +- 29	283 +- 28	276 +- 28	1120 +- 60
B	10m	220 +- 22	232 +- 23	244 +- 24	240 +- 24	940 +- 50
B	15m	193 +- 19	215 +- 21	217 +- 22	209 +- 21	830 +- 40
B	20m	182 +- 18	217 +- 22	213 +- 21	205 +- 20	820 +- 40
B	25m	161 +- 16	192 +- 19	208 +- 21	204 +- 20	760 +- 40
B	50m	147 +- 15	181 +- 18	185 +- 19	170 +- 17	680 +- 30
B	75m	155 +- 15	169 +- 17	169 +- 17	166 +- 17	660 +- 30
B	100m	181 +- 18	203 +- 20	211 +- 21	189 +- 19	780 +- 40
B	150m	163 +- 16	185 +- 19	181 +- 18	174 +- 17	700 +- 40
B	200m	179 +- 18	182 +- 18	180 +- 18	168 +- 17	710 +- 40

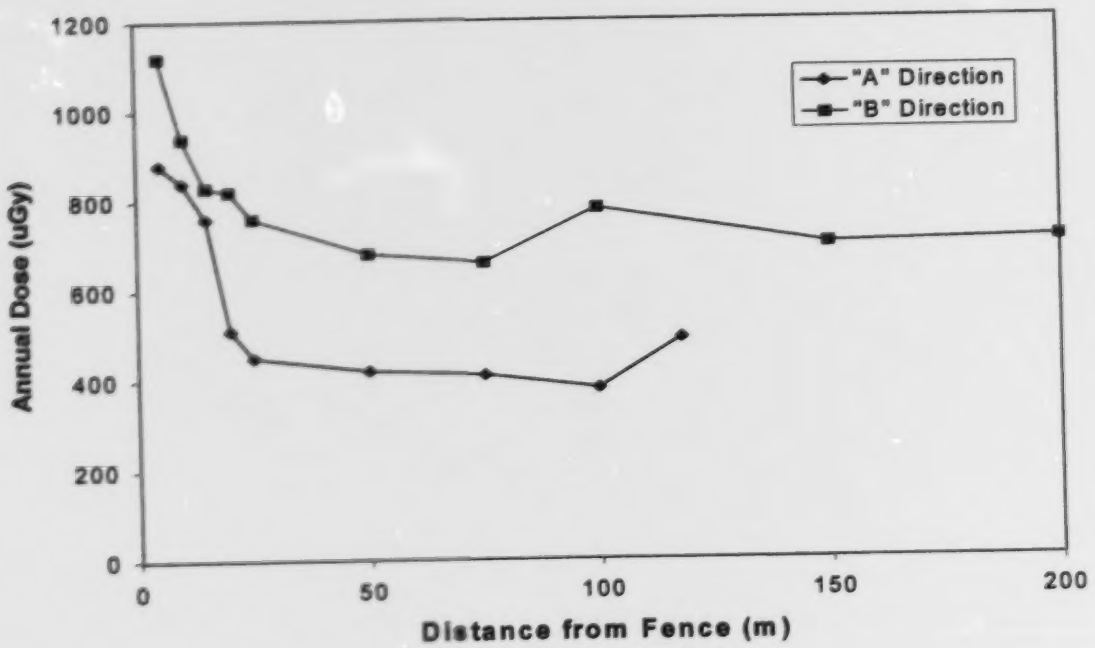


Figure 4.17
Drop-off TLDs

4.30 Meteorological Data

The meteorological data for 1998 and a compilation of the available 1986 to 1998 data, from the 42 metre elevation, at the Point Lepreau Generating Station are presented in Tables 4.31 and 4.32. Over the 13 year period, there was approximately one year, during which data were generally unavailable. Data were collected hourly. Wind Rose data for 1998 are presented in Figure 4.18 and a pie-plot of the average percentage frequency of Pasquill stability classes for the years from 1986 to 1998 in the Point Lepreau area is presented in Figure 4.19.

Table 4.31
Meteorological Data For Point Lepreau (1998)

	Temperature					Wind direction								Pasquill Stability Classes							
	Degrees Celsius					Relative %								Relative %							
		Mean Daily		Extreme		%Observations from															%
Month	Av	Max	Min	Max	Min	N	NE	E	SE	S	SW	W	NW	A	B	C	D	E	F	G	UNAV
January	-5.6	-2.3	-8.8	7.4	-18.9	16	3	7	3	5	8	24	33	63	18	8	7	2	1	2	44
February	-2.0	0.5	-5.0	6.0	-16.3	28	15	4	3	7	9	15	20	61	11	5	8	7	4	3	18
March	-0.5	2.5	-3.2	15.1	-15.1	16	18	4	6	11	17	13	14	65	10	4	6	6	4	4	0
April	4.1	6.7	1.8	11.9	-2.2	25	15	2	4	14	14	11	16	62	6	3	8	8	6	6	7
May	8.8	12.1	6.1	18.9	2.0	6	35	5	8	20	16	6	3	57	7	5	8	9	10	5	13
June	10.4	13.1	8.3	18.0	5.6	7	26	8	12	21	11	10	4	66	5	5	9	8	4	3	0
July	13.6	16.7	11.4	23.6	8.5	1	4	5	20	27	26	14	3	56	4	3	8	11	6	11	10
August	14.6	17.5	12.3	22.7	10.4	7	11	3	9	27	24	12	8	54	6	5	10	9	6	10	6
September	12.7	14.8	10.6	21.0	6.1	7	13	6	8	19	17	19	11	56	8	4	9	14	6	3	13
October	7.3	9.5	5.3	16.5	-0.1	20	7	1	6	15	11	21	19	61	9	8	10	4	2	5	19
November	2.5	5.0	0.1	9.5	-8.5	11	3	8	5	8	15	33	18	60	11	9	12	6	3	0	6
December	-0.6	3.3	-4.6	12.9	-21.5	10	11	3	8	8	12	32	16	68	9	7	8	5	1	0	34
Means	6.0	8.8	3.5	23.6	-21.5	13	14	5	8	16	15	17	13	61	8	5	9	8	5	5	14
Years	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

42 Metre Tower data

*Each compass direction covers ±22.5 degrees

UNAV: The percentage of time that the instrumentation was unavailable and could not record the weather.

Table 4.32
Meteorological Data For Point Lepreau
(thirteen year average)

	Temperature					Wind direction								Pasquill Stability Classes							
	Degrees Celsius					Relative %								Relative %							
		Mean Daily		Extreme		%Observations from															%
Month	Av	Max	Min	Max	Min	N	NE	E	SE	S	SW	W	NW	A	B	C	D	E	F	G	UNAV
January	-5.6	-1.6	-9.6	8.8	-27.4	12	7	4	5	9	15	24	24	38	10	8	19	14	8	4	9
February	-5.7	-2.0	-9.7	7.3	-25.1	17	7	3	4	10	17	19	23	38	11	9	18	13	6	4	10
March	-1.8	1.2	-4.9	15.1	-24.9	18	10	4	7	14	14	15	18	34	8	8	19	17	8	5	6
April	2.8	5.5	0.6	16.4	-14.6	20	17	6	7	16	12	12	11	35	6	6	19	20	8	5	10
May	7.3	10.5	5.0	25.6	-1.7	14	14	5	8	22	20	9	8	33	5	6	15	21	11	9	11
June	11.1	14.3	8.7	26.1	4.1	10	13	7	9	21	21	11	8	27	4	4	14	24	15	12	10
July	13.9	17.0	11.5	27.3	6.9	4	9	6	11	25	28	11	6	23	3	3	12	22	18	19	8
August	14.7	17.5	12.4	28.4	7.5	7	8	4	10	24	24	14	9	26	4	3	11	20	19	17	7
September	12.2	14.6	10.0	26.3	1.1	9	7	4	8	21	21	16	14	25	4	4	15	25	17	9	19
October	8.0	10.4	5.7	18.9	-3.6	12	7	6	8	17	16	19	16	30	5	6	20	19	12	8	8
November	2.5	5.4	-0.4	14.7	-13.7	14	6	5	7	9	13	25	22	31	8	8	23	16	9	3	2
December	-3.1	0.6	-6.8	12.9	-21.5	15	5	4	5	7	12	25	26	37	11	10	20	14	6	3	9
Means	4.7	7.9	2.0	28.4	-27.4	13	9	5	7	16	18	17	15	31	7	6	17	19	12	8	9
Years	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13

42 Metre Tower data

*Each compass direction covers ±22.5 degrees

UNAV: The percentage of time that the instrumentation was unavailable and could not record the weather.

Figure 4.18
Wind Rose For Point Lepreau
(1998)

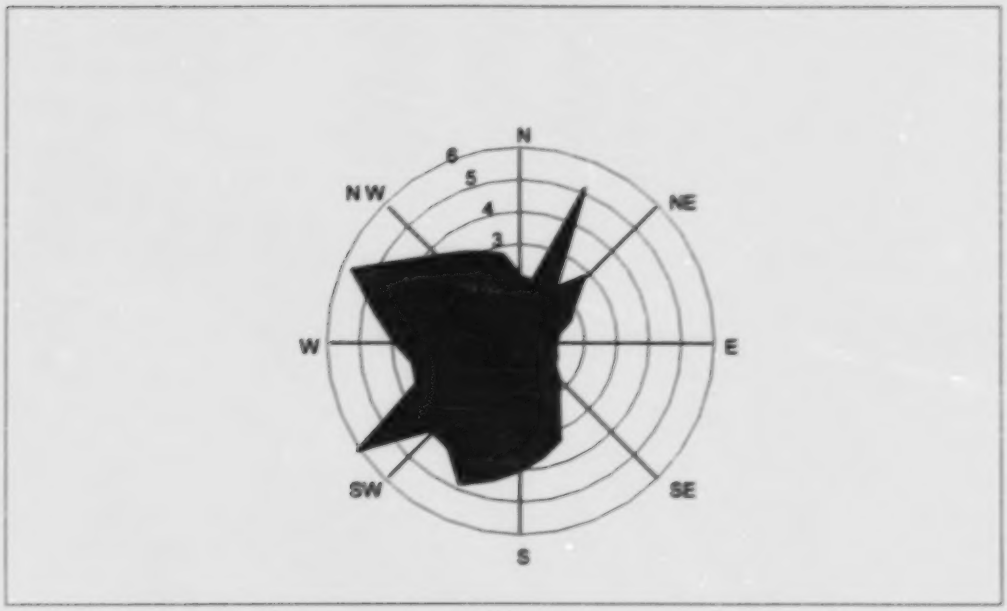
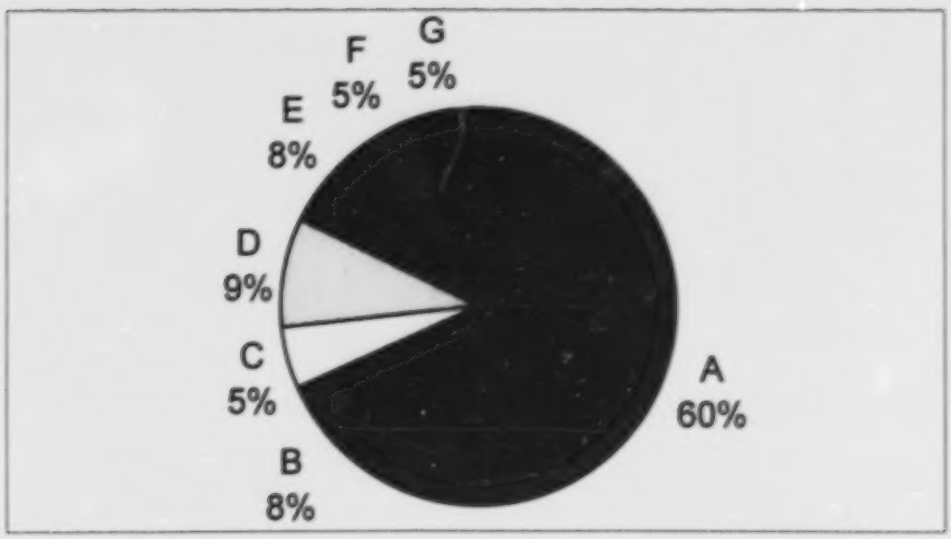


Figure 4.19
Pasquill Stability Factors For Point Lepreau
(1998)



5.0 Trends

The only trends that were obvious from the historical data and continued in 1998 were increasing H-3 in Parshall Flume water and higher ambient gamma near the SRWMF.

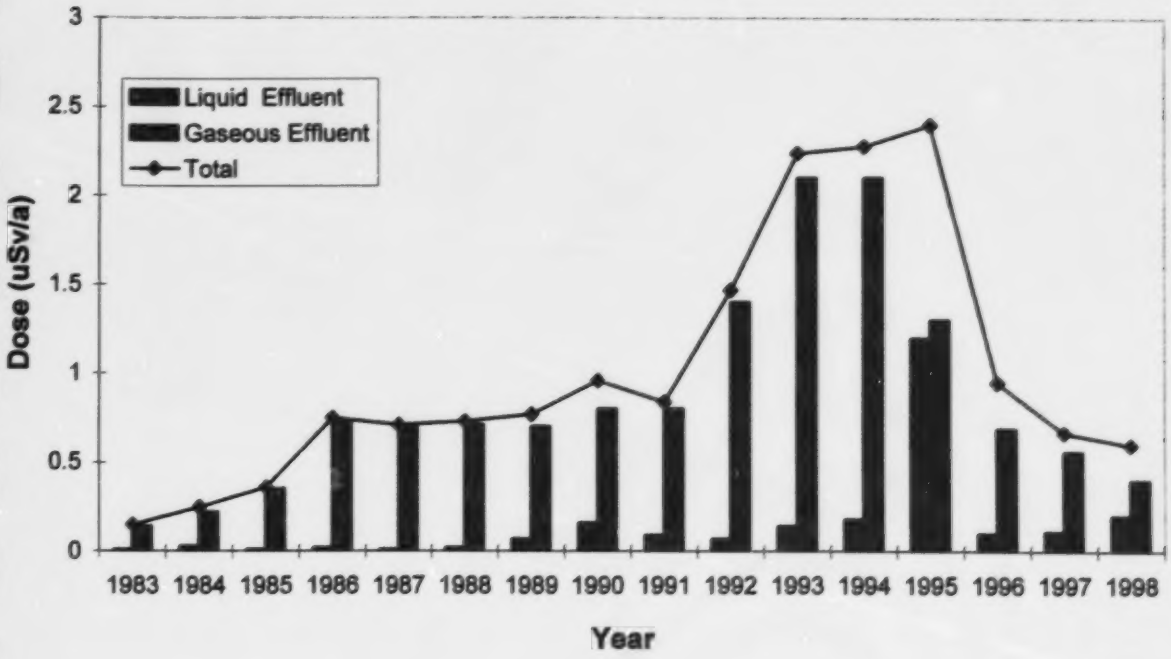


Figure 5.01
Historical Dose from Gaseous and Liquid Pathways

A plot of the gross beta data from 1976 to 1998 at Dipper Harbour, about 4 km from the PLGS stack and in the predominant downwind direction, is presented in Figure 5.05. The baseline data show the naturally occurring radioactivity in the area. The peaks on the plots correspond to fallout from various atmospheric bomb tests which were most common in the 1950s and 1960s but decreased into the 1970s. Fallout from the Chinese atmospheric bomb test in October of 1980 (fallout occurred in 1981 in N.B.), and from the Chernobyl accident in April 1986, were obvious. Figure 5.04 shows a comparable plot of data from Health and Welfare Canada, but for the whole of Canada from 1959 (when data were first collected) to 1991. The scale is very much condensed to allow the significant, but relatively small, bomb test fallout levels to be kept on-scale.

The Chernobyl accident released, in a period of a few days, about 1% as much radioactivity to the environment as all of the U.S. atmospheric bomb tests combined, released over several years.

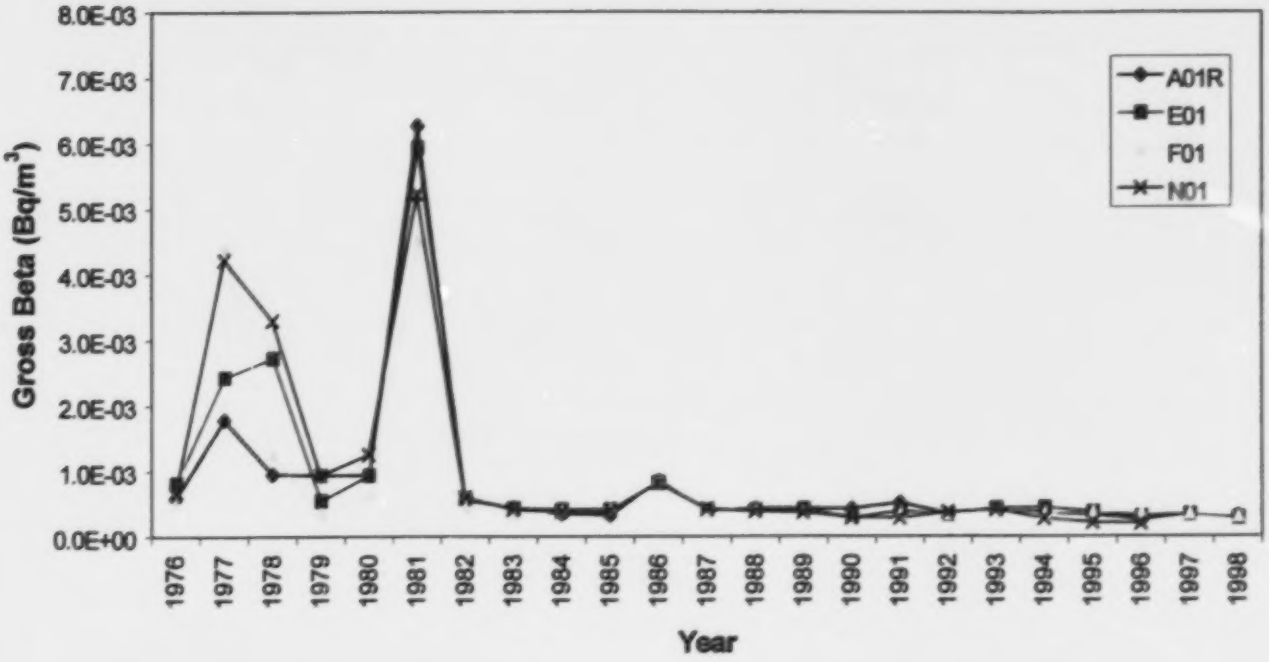


Figure 5.02 Historical Gross Beta in Air (Offsite Air Stations)

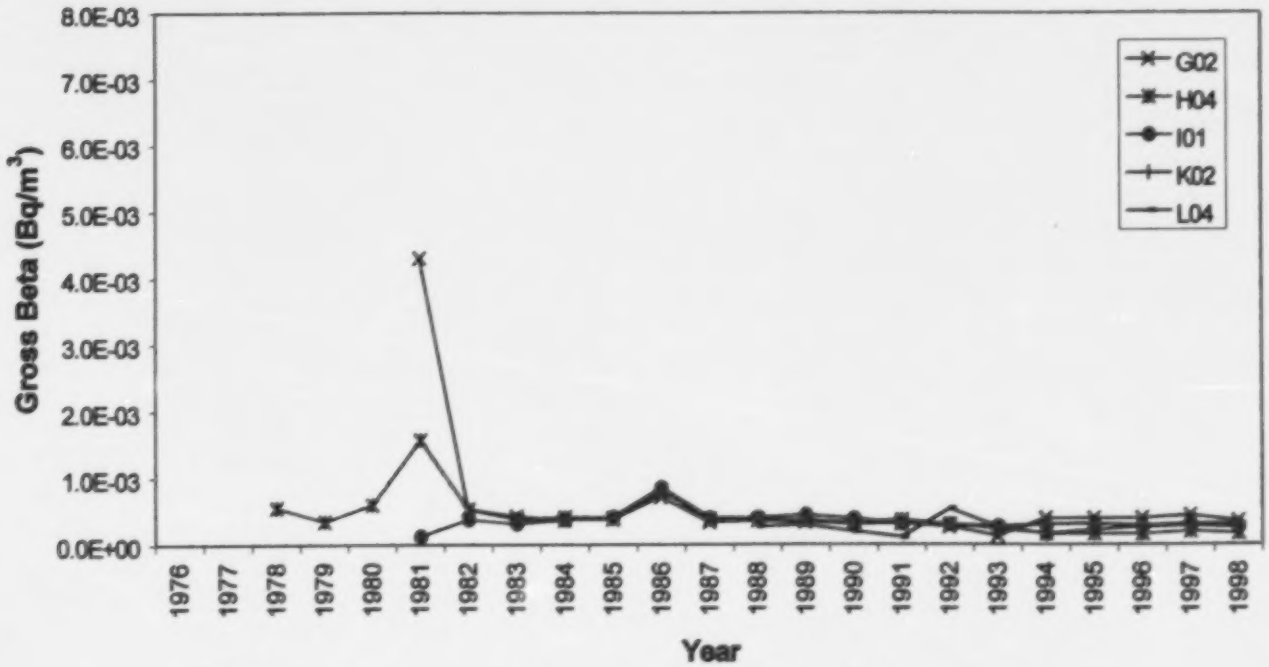


Figure 5.03 Historical Gross Beta in Air (Onsite Air Stations)

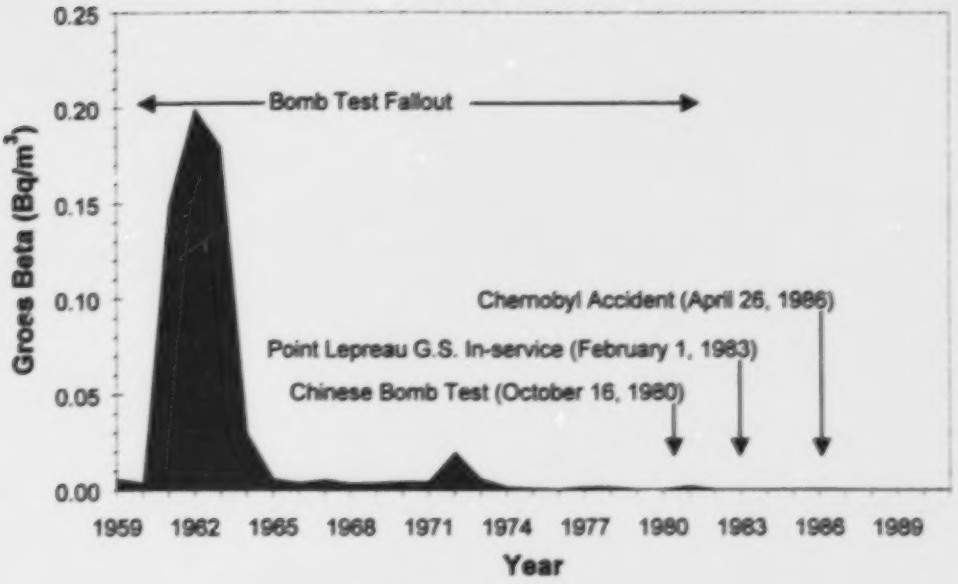


Figure 5.04
Annual Average Gross Beta Activity in Air for Canada 1959 to 1991 (Health and Welfare Canada Data)

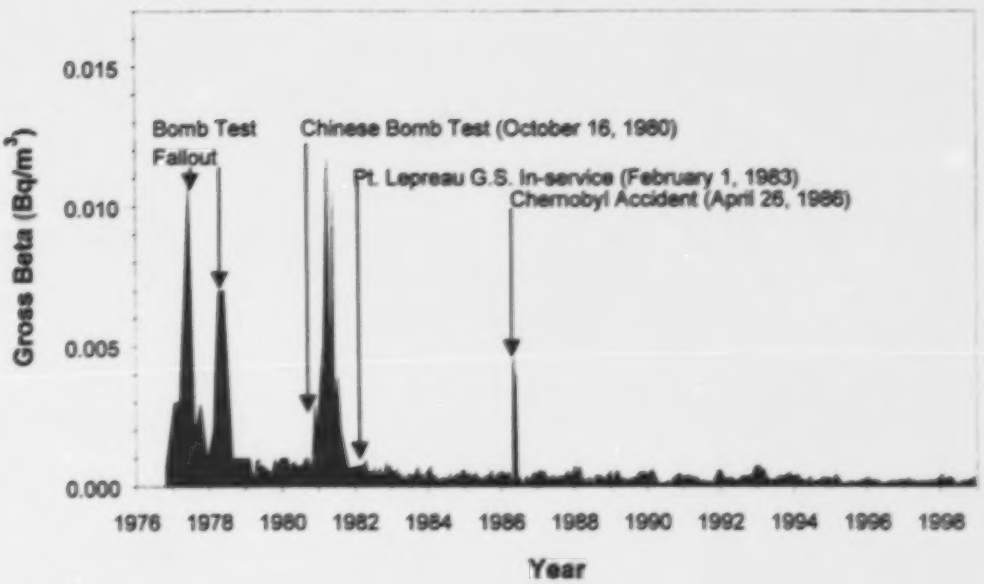


Figure 5.05
Gross Beta Activity in Air at Dipper Harbour

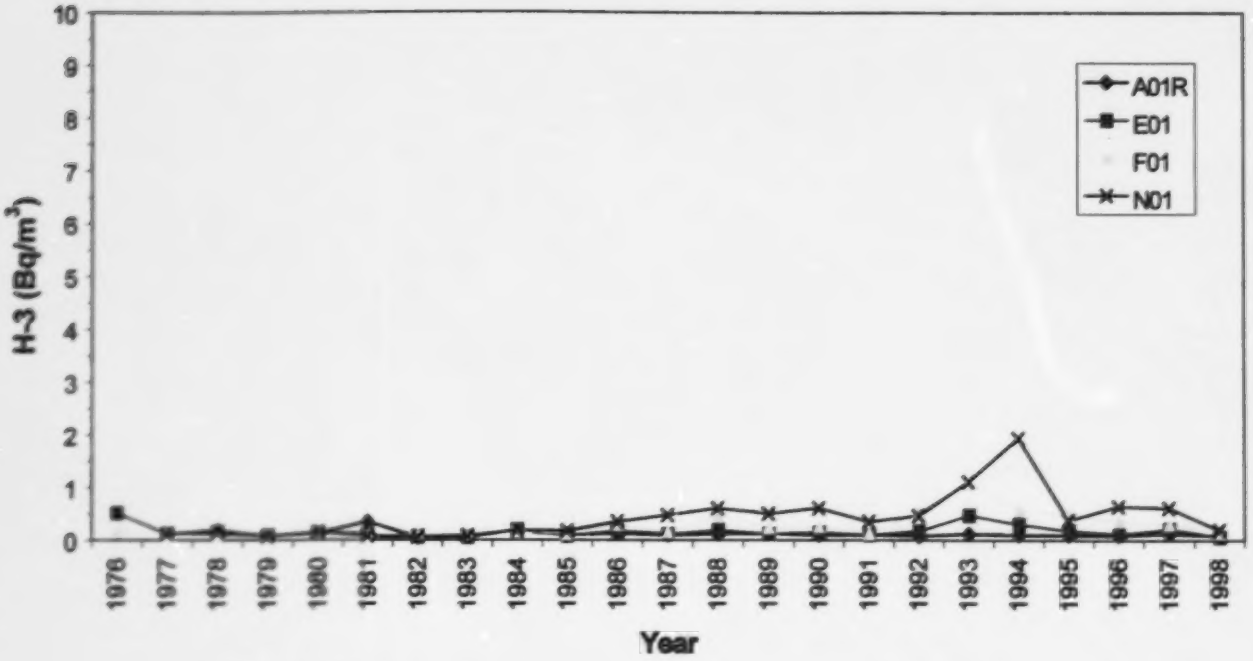


Figure 5.06 Historical Tritiated Water in Air (Offsite)

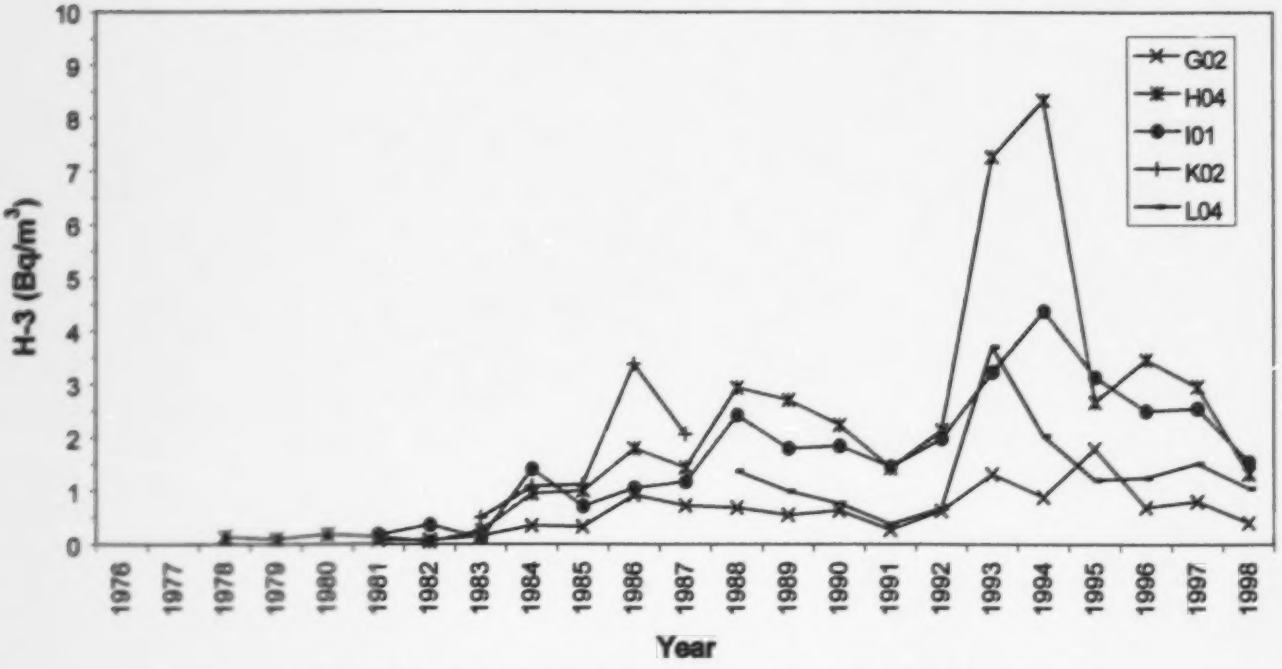


Figure 5.07 Historical Tritiated Water in Air (Onsite)

The annual average dispersion factor for stack emissions up to this time is between 1E-7 and 2E-7 s/m^3. This factor is based upon the data for H-3. A value of 2E-7, based on such empirical data, is used in the DEL calculations. Results since 1984 are presented in Table 5.01.

Table 5.01
Average Atmospheric Dispersion Factor for Each Air Monitoring Location (1)

Location	E01 Maces Bay	F01 Welch Cove	G02 Light-house	H04 Duck Cove *	I01 SRWMF	K02 Pump-house	L04 Stores	N01 Dipper Hrbr.
km from stack	4.5	1.5	1.0	0.8	1.0	0.2	0.6	3.8
Year (+)			Dispersion Factors: s/m^3					
1984 (6.8E13)	8E-8	8E-8	2E-7	5E-7	7E-7**	5E-7		8E-8
1985 (1.1E14)	2E-8	4E-8	9E-8	3E-7	2E-7	3E-7		5E-8
1986 (2.0E14)	3E-8	5E-8	1E-7	3E-7	2E-7	5E-7		6E-8
1987 (2.2E14)	2E-8	2E-8	1E-7	2E-7	2E-7	3E-7		7E-8
1988 (2.2E14)	3E-8	7E-8	1E-7	4E-7	3E-7	#	2E-7	9E-8
1989 (2.1E14)	2E-8	4E-8	8E-8	4E-7	3E-7	#	2E-7	8E-8
1990 (2.5E14)	2E-8	3E-8	8E-8	3E-7	2E-7	#	1E-7	8E-8
1991 (1.7E14)	2E-8	3E-8	5E-8	3E-7	3E-7	#	7E-8	7E-8
1992 (3.6E14)	2E-8	5E-8	5E-8	2E-7	2E-7	#	6E-8	4E-8
1993 (6.4E14)	2E-8	5E-8	6E-8	4E-7	2E-7	#	2E-7	5E-8
1994 (5.6E14)	2E-8	3E-8	5E-8	5E-7	2E-7	#	1E-7	1E-7
1995 (3.1E14)	2E-8	5E-8	2E-7	3E-7	3E-7	#	1E-7	4E-8
1996 (2.4E14)	2E-8	5E-8	9E-8	5E-7	3E-7	#	2E-7	8E-8
1997 (2.1E14)	3E-8	5E-8	1E-7	4E-7	4E-7	#	2E-7	9E-8
1998 (1.3E14)	9E-9	2E-8	6E-8	2E-7	2E-7	#	2E-7	E-8

\+ becquerel of tritium as tritiated water, emitted during the year.
(1) Excluding the Reference location A01R.
* This location was identified as 'Information Centre' in previous reports.
** This value includes a second source term: H-3 from containers temporarily located in this facility in 1984 and picked up by the air sampler (ignored in the calculation of the normalised mean dispersion factor).
\# no longer in use. This monitoring station was relocated to L04 - the Construction Stores Compound - in the spring of 1988.

In the calculation of the mean dispersion factor at each location, the average recorded is now the average of the detected values and the "less than" values. This will give a conservative estimate of the true value (i.e. less dispersion of the radionuclides).

To derive a normalised mean dispersion factor at 1 km from the stack for all locations,

each dispersion factor value is corrected to 1 km. This is accomplished by tracing back between dispersion curves on the graph of "Weighted Mean Dilution Factor versus Distance from the Point of Continuous Emission"[8] (reproduced in the DEL licensing document referred to previously). The average of these normalised values is presented in Table 5.02.

Table 5.02
Normalised Mean Dispersion Factor
At 1 km For All Indicator Locations

Year	s/m^3
1984	2E-07
1985	1E-07
1986	1E-07
1987	1E-07
1988	2E-07
1989	2E-07
1990	1E-07
1991	1E-07
1992	1E-07
1993	1E-07
1994	1E-07
1995	2E-07
1996	2E-07
1997	2E-07
1998	1E-07
Average over 15 years	<2E-07

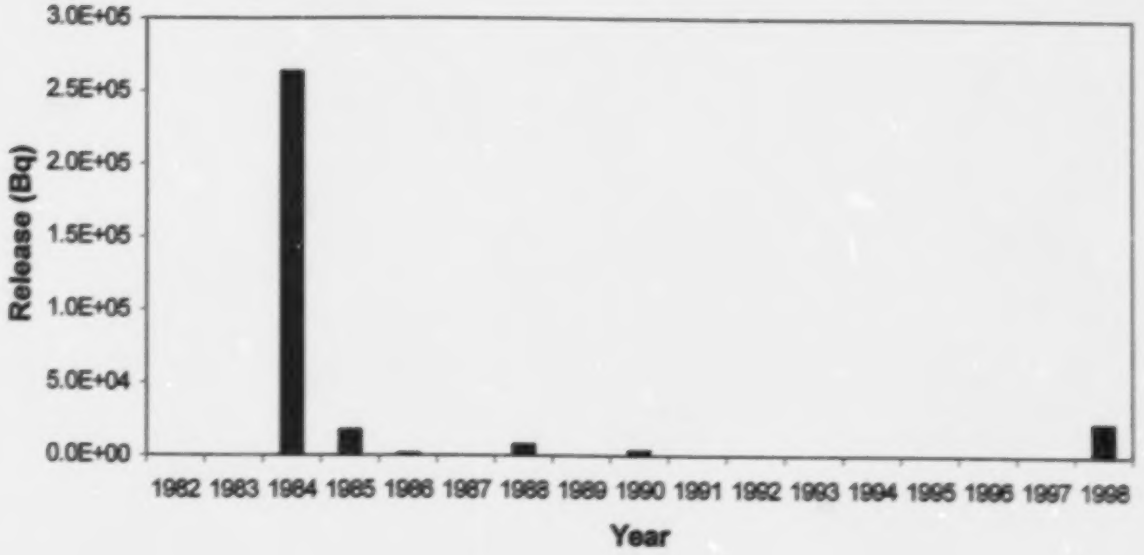


Figure 5.08
Historical Sr-90 in Air (GEM)

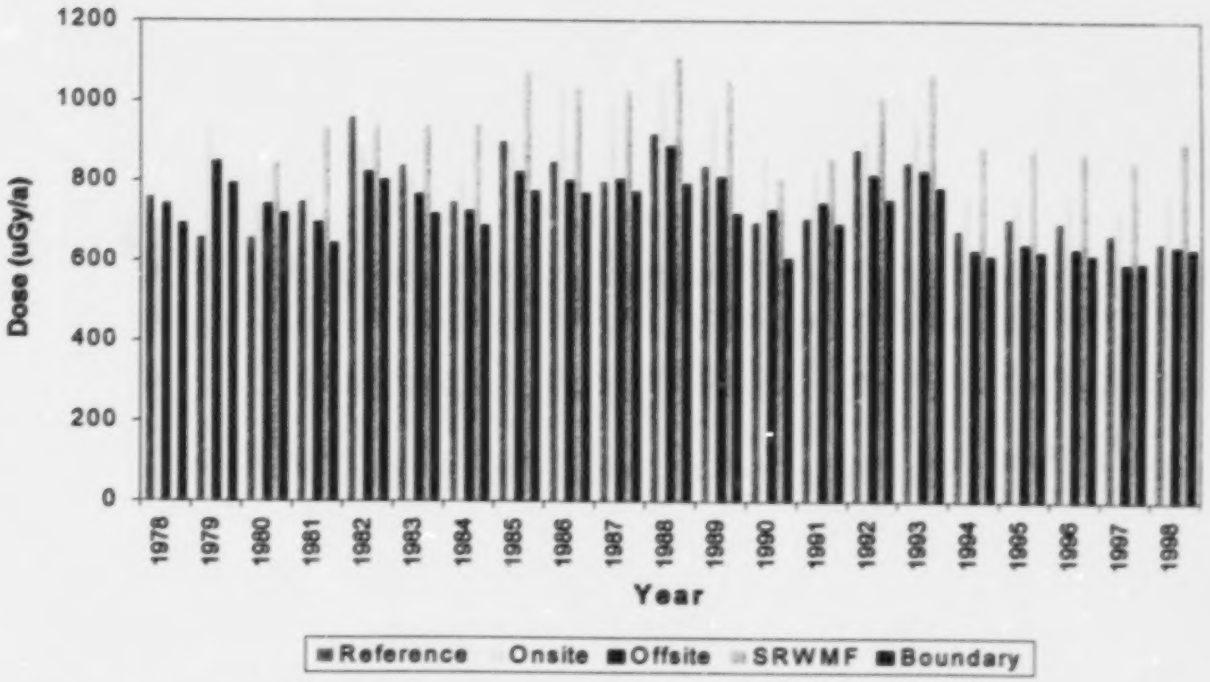


Figure 5.09
Historical TLD Measurements

Environmental Gamma Radiation

A plot of TLD data at specific locations since 1978 is presented in Figure 5.09. This is a summary of data obtained at each location since 1978 . There is only one reference location (A01R in Bocabec) while the other groups are the average of many locations. Dosimeters are also in place in two directions from the boundary fence of the SRWMF Phase 2 facility to measure drop-off of radiation from the filled dry fuel storage canisters with distance, to about 200 metres. Results are presented in Figure 5.21.

The variation in natural background radiation at any individual location covers a range of about 300 microsieverts from year to year. A few locations close to the reactor building (e.g. J70) and the air emissions stack show significant, but small, increases in gamma radiation due to chronic releases of low levels of noble gases. In 1995, the extended outage resulted in fewer noble gas emissions and thus lower dose measured by these TLDs. Small increases at the SRWMF are due to compacted, mostly low-level waste and used fuel emplacement respectively, and not to station emissions.

Background radiation in any of the monitored residential areas has not increased from the levels measured before the Point Lepreau Generating Station was placed into operation. The last five years of measurements were taken with new environmental TLDs.

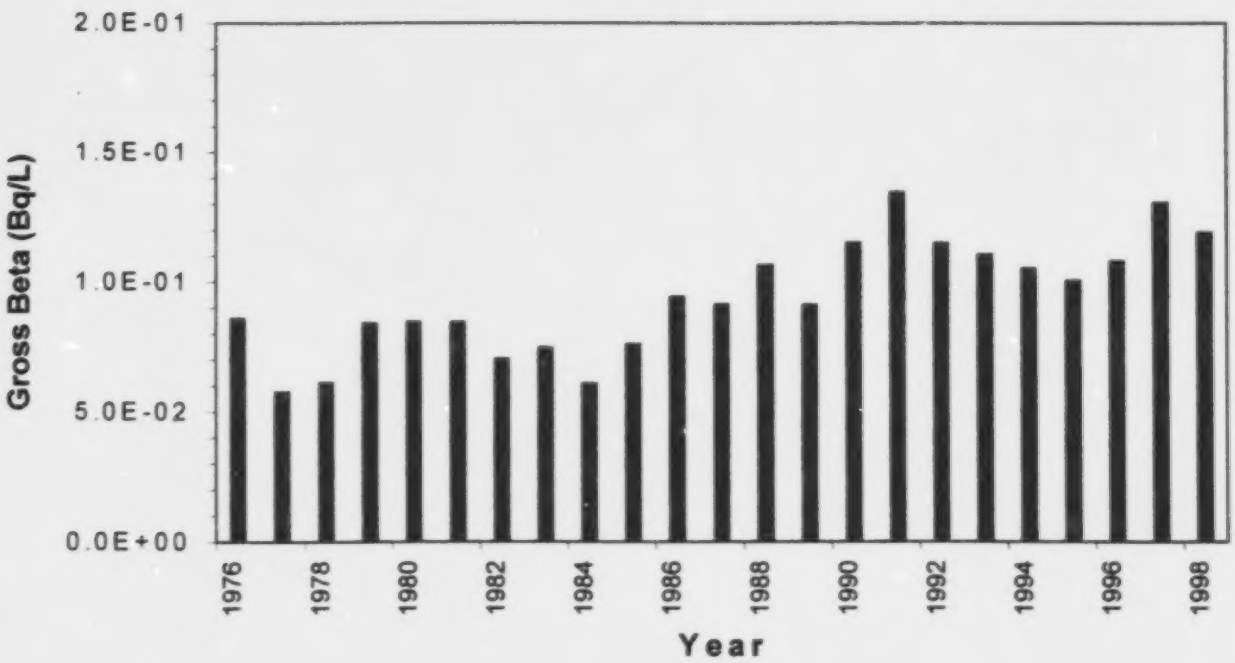


Figure 5.10 Historical Gross Beta in Well Water

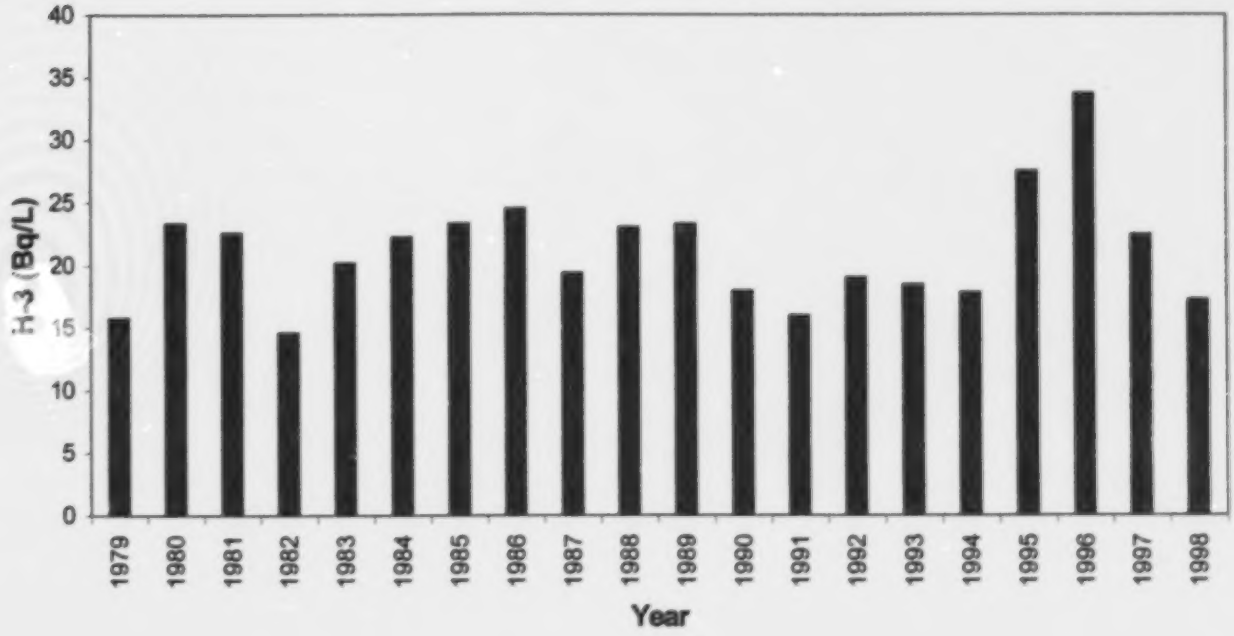


Figure 5.11 Historical Tritium in Well Water

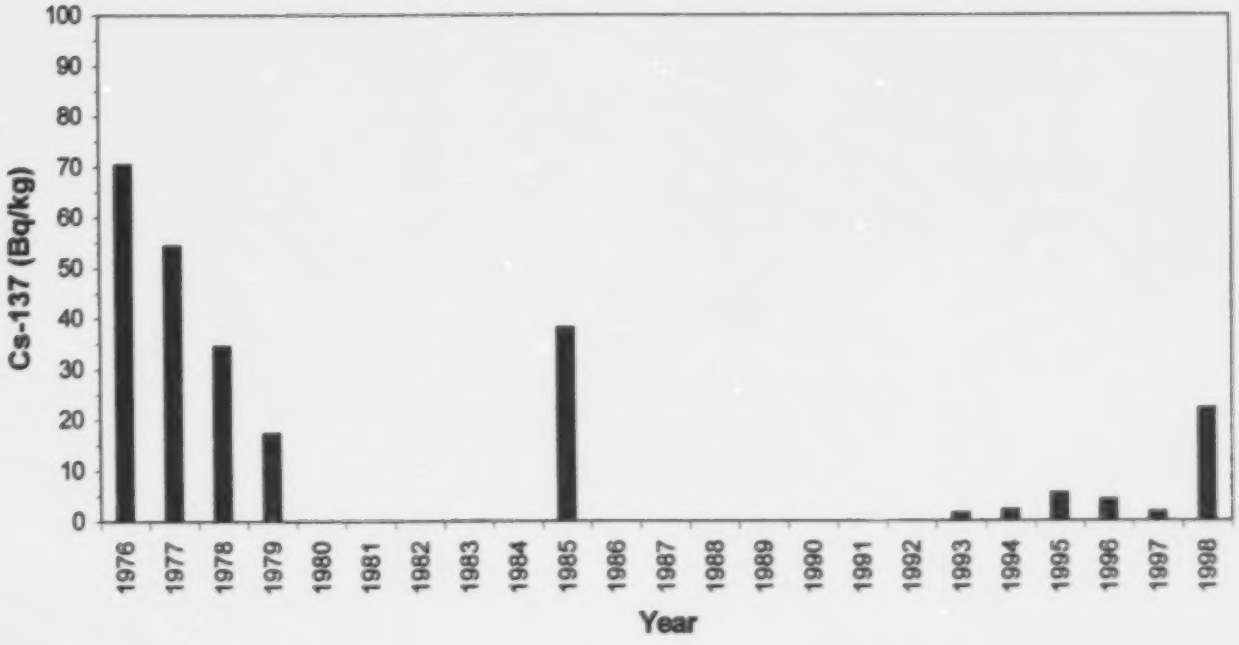


Figure 5.12 Historical Cs-137 in Soil

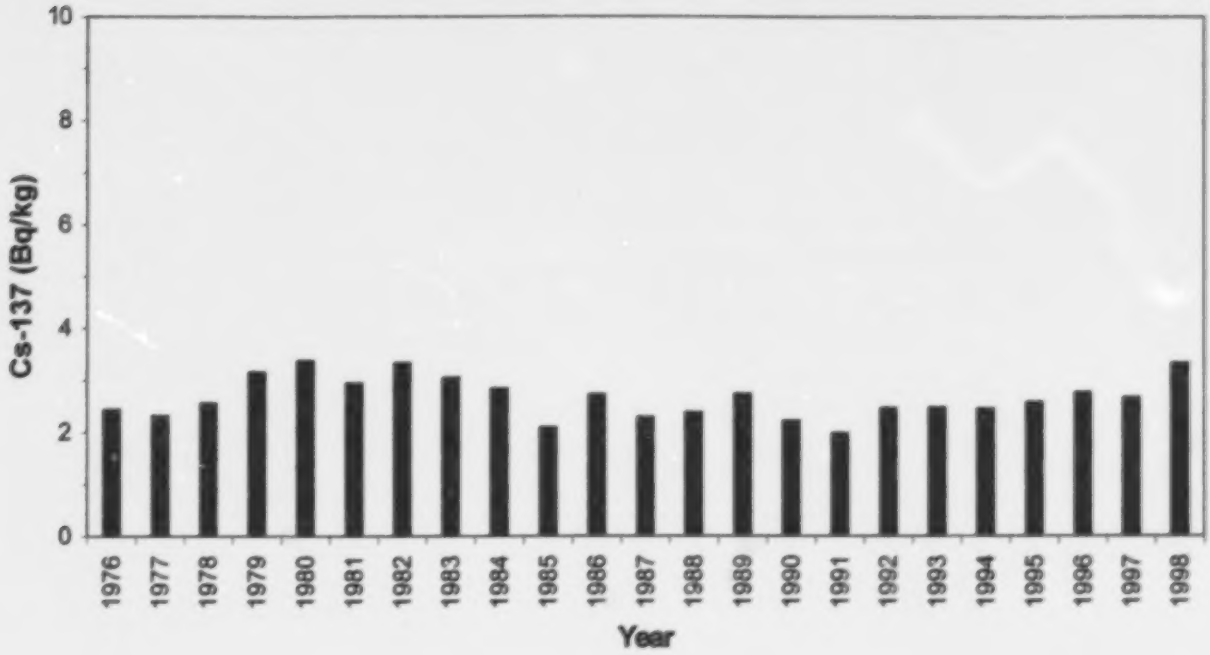


Figure 5.13 Historical Cs-137 in Sediment

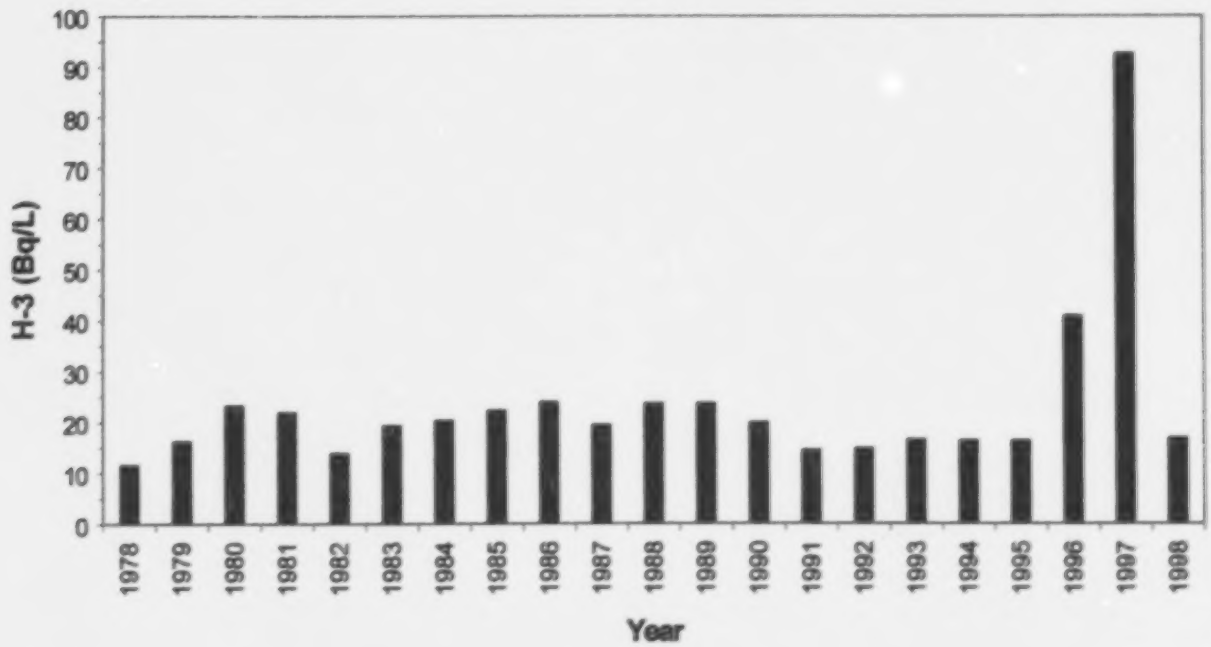


Figure 5.14 Historical Tritium in Seawater

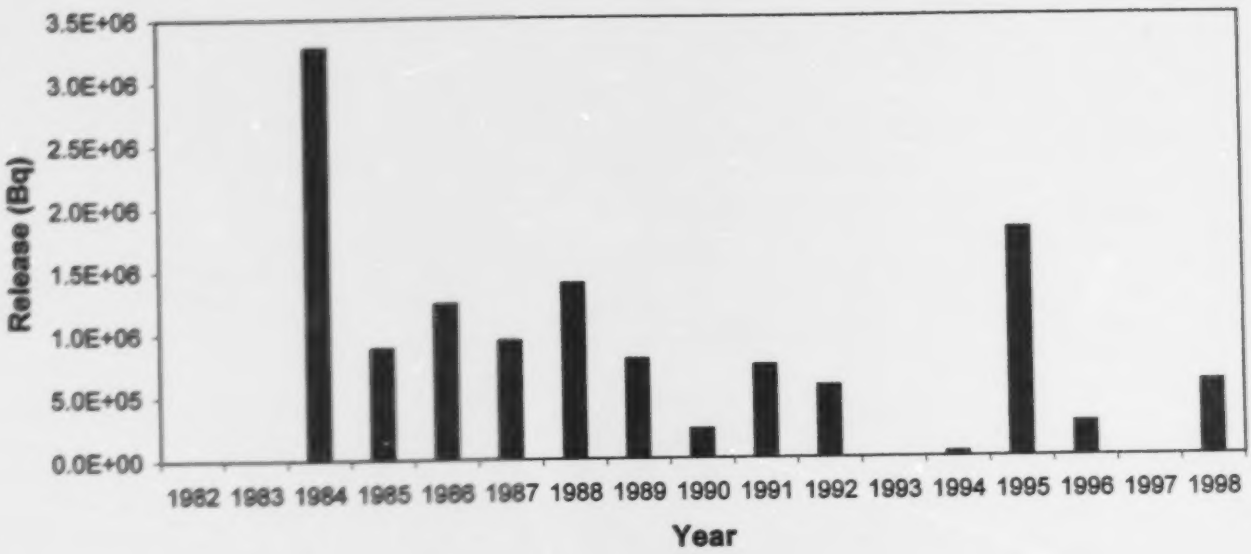


Figure 5.15 Historical Sr-90 in LEM

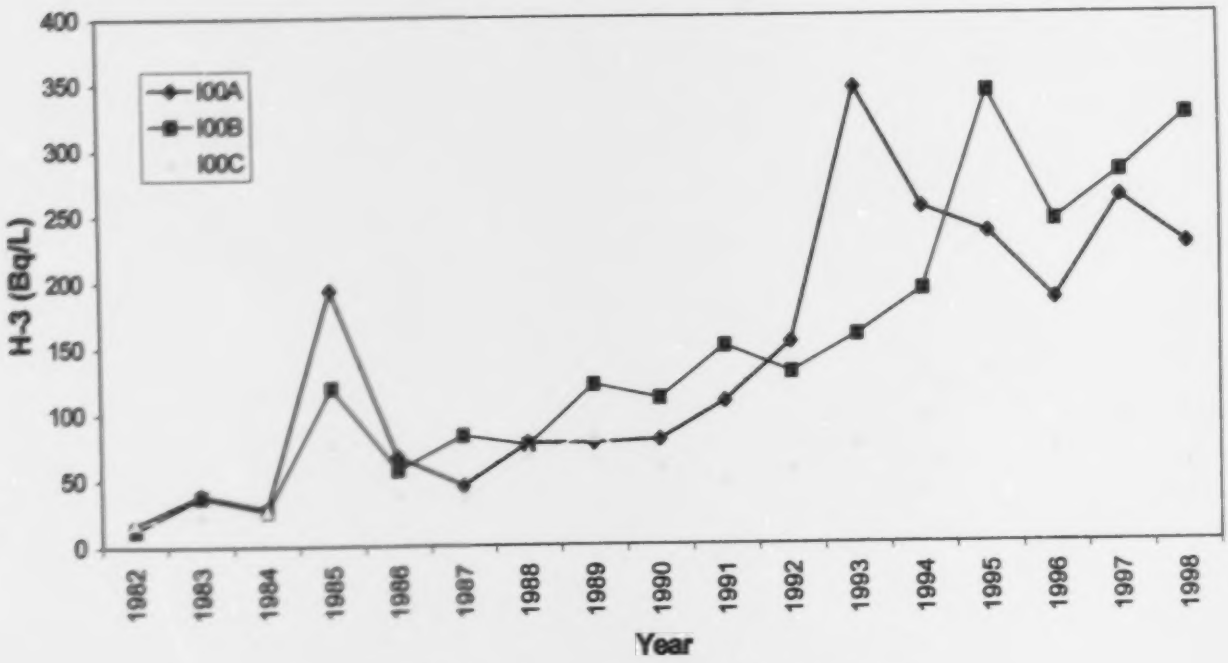


Figure 5.16 Historical H-3 in Bore Holes

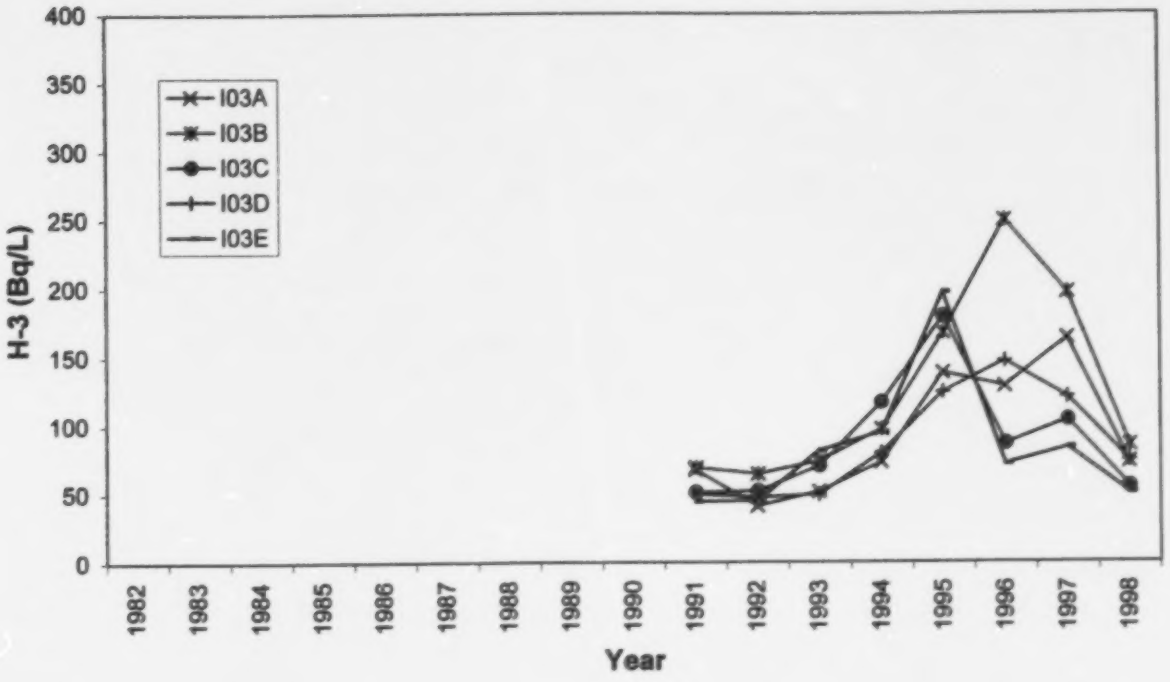


Figure 5.17 Historical H-3 in Bore Holes

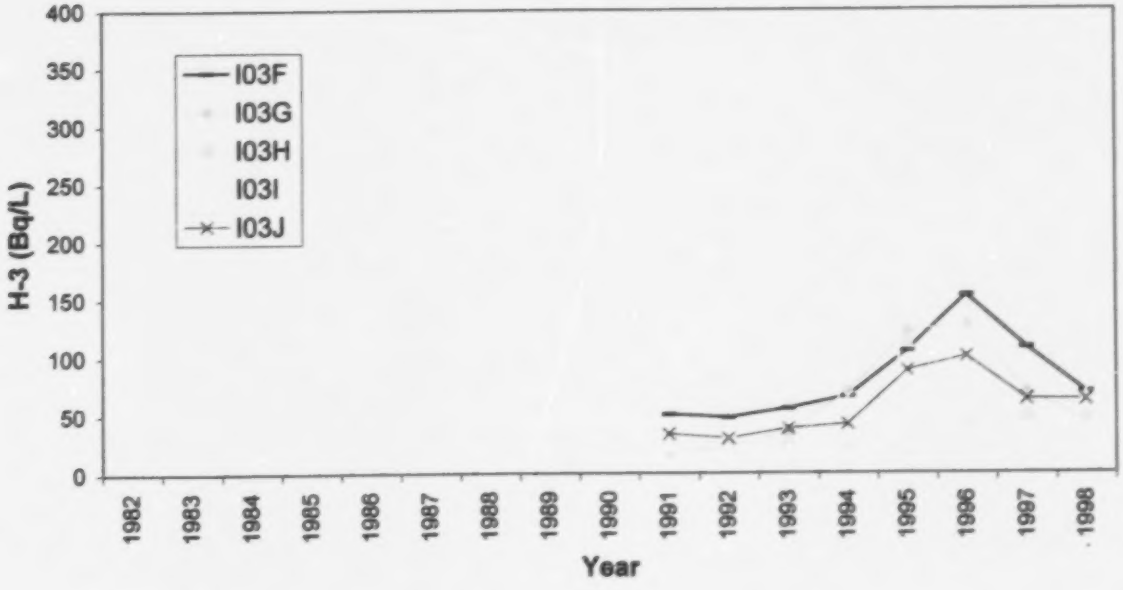


Figure 5.18 Historical H-3 in Bore Holes

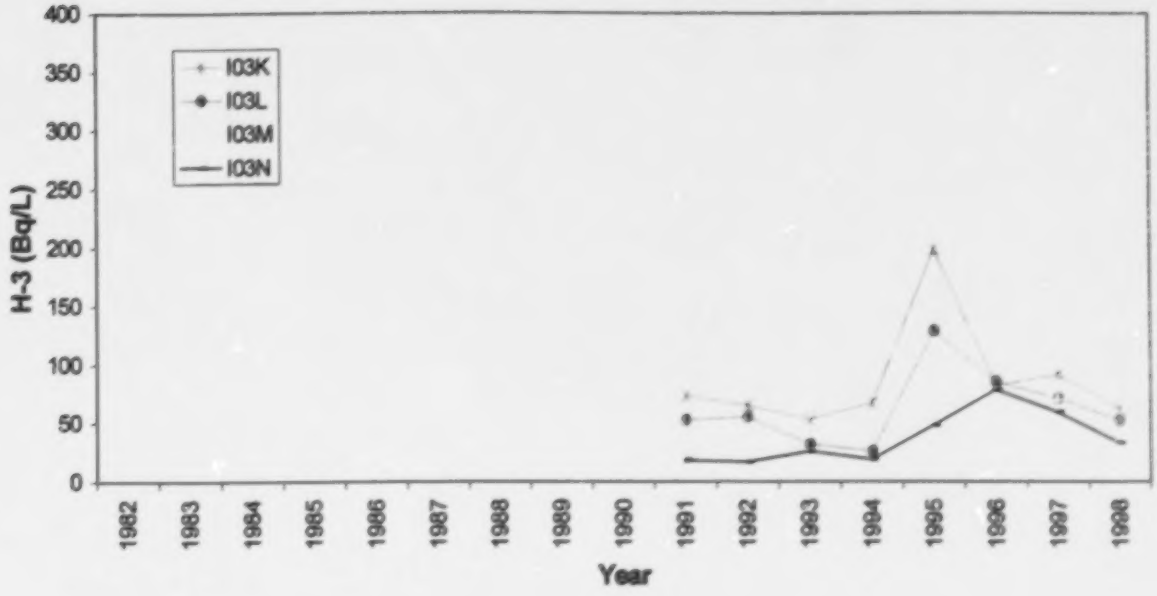


Figure 5.19 Historical H-3 in Bore Holes

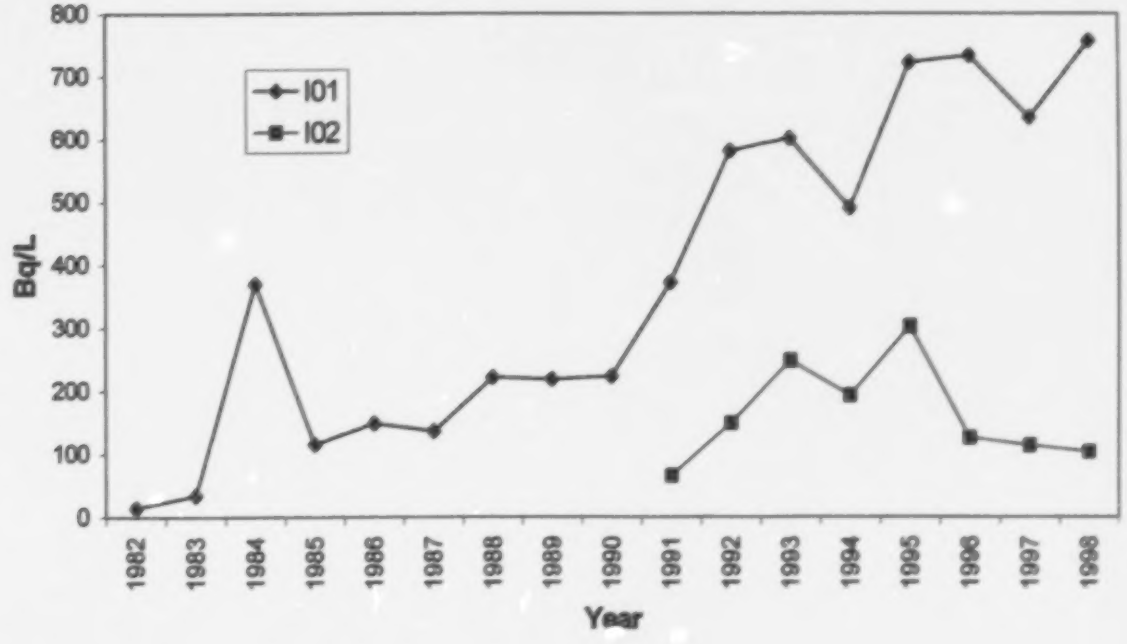


Figure 5.20 Historical H-3 in Parshall Flumes

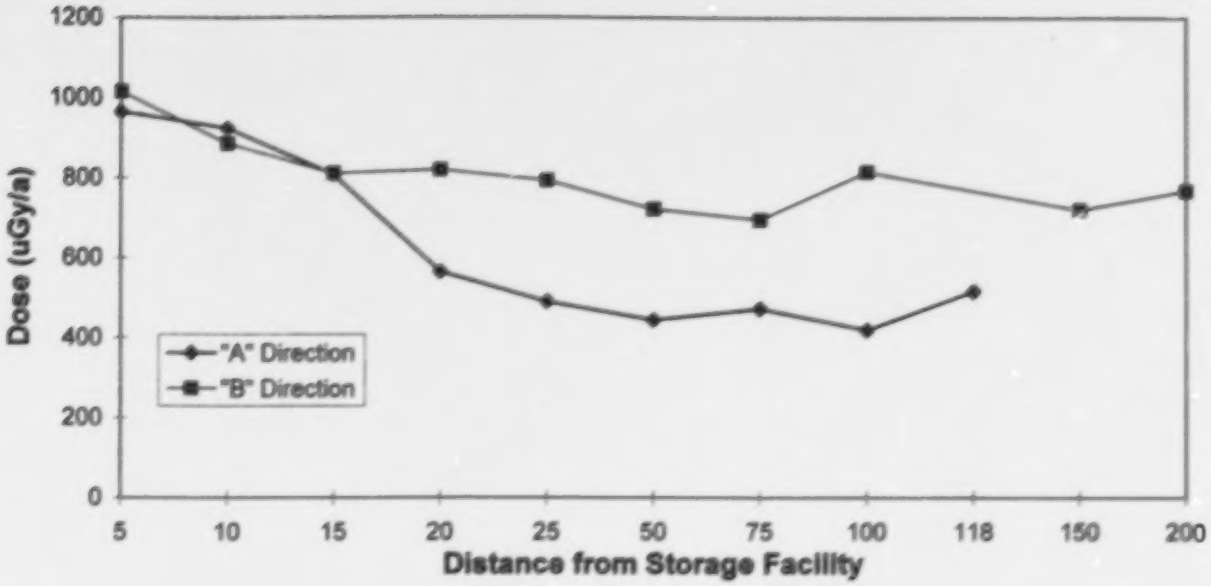


Figure 5.21 Historical Drop off TLDs

Comments on Trends

Some of the tables require further comment. As opposed to Section 4, only detected values are plotted (i.e. not "Critical Levels"). All location codes are described in Appendix C.

Tables 5.08 and 5.15 – The maximum values for Sr-90 still represent only a small fraction of the DEL and are due to activity detected just above the detection limit. Multipying these numbers by the large volumes of air and liquid released make these numbers appear larger than they are.

Table 5.12 – There were no soil samples from 1986 to 1992.

Table 5.14 – The increase in H-3 in 1996 and 1997 were due to samples being taken directly over the outfall. These samples are usually taken at the shore.

Table 5.21 – Each point on the graph is the average for all the years the facility has operated.

6.0 Dose Estimation

Based upon the total percent DEL for all monitored radionuclides in each pathway for 1998, the calculated annual whole body radiation dose to members of the Critical Groups was about 0.2 μSv from liquid emissions and about 0.4 μSv from airborne emissions. This latter calculation allows for the actual location of an existing dairy herd in 1998 at about 40 km, rather than assuming the existence of a hypothetical herd at 1.5 km. This results in a dose reduction factor of about 12 for C-14 in the milk pathway because of the differences in dispersion factors between 1.5 km and 40 km (6E-08 s/m^3, and 5E-09 s/m^3 respectively).

Because of the protective assumptions used in the DEL calculations, and the relatively low level of emissions, the most exposed member of the general public received far less than the calculated dose. This radiation dose may be compared with the individual natural radiation dose in the Point Lepreau area of approximately 2000 to 3000 microsieverts per annum (TLDs show only the external, penetrating component, amounting to about 500 to 1000 microsieverts). This includes natural dose contributions from ground, air, food and from an assumed low concentration of radon in homes. A significant fraction of Canadian homes contain radon levels that give a radiation dose much larger than this. In addition, the average annual medical radiation dose is about 350 μSv per person.

Table 6.01
Annual Dose

Source of Dose to Critical Group	*Individual Dose (μSv/a)*	*Population Dose (person-mSv/a)*
PLGS gaseous emissions	0.4	1.5
PLGS liquid emissions	0.2	0.8
natural background	2000	320000
medical procedures	------	80000

The only assessable radiation dose from PLGS on the local population is that from tritiated water vapour in air. This continues to be detected offsite in air and water samples.

Population dose is the summation of all calculated doses over the entire population within a 20 km radius from PLGS for the seafood pathway, and within a 60 km radius from PLGS for the airborne pathway. This population dose is 0.8 person-millisievert in the seafood pathway and about 1.5 person-millisieverts in the airborne pathway, for a population total of 2.3 person-millisieverts. This is insignificant when compared with the population dose of about 320 000 person-millisieverts that this same group receives from natural background radiation, and an additional 80 000 person-millisieverts received by some of this population from radiation used in medical treatments.

7.0 Quality Assurance Results

7.1 Introduction

The Quality Assurance (QA) program faced challenges in 1998 from a reduction in blind samples from the United States Environmental Protection Agency (USEPA) and Atomic Energy of Canada Limited (AECL). This deficiency was balanced by an increase in other QA activity.

The capability of the radiation monitoring laboratory is assessed through participation in Quality Assurance programs, when available. The programs offered by the USEPA were not available in Canada in 1995 because of restrictions on sample shipping, but started up again in 1996 at a reduced frequency. In the future, the EPA will discontinue this QA testing program. Alternative testing programs were initiated with other laboratories in Canada to fill this gap. Analytical checks are conducted daily, and the use of indicator radionuclides such as K-40 shows that the analyses are reproducible.

Environmental monitoring for the Point Lepreau area has been conducted in previous years by the Bedford Institute of Oceanography (Dartmouth, Nova Scotia) and the Federal Department of Health (Ottawa). The analytical results reported by these agencies were comparable with those reported by NB Power for similar samples.

The laboratory also contracted out its services in 1998 for several clients. A calibration standard was run with each set of samples to indicate to the customer the reliability of the results. These results are presented in Figure 7.01. This process, combined with the general agreement between the results we reported to the customer and their own results, provides an extra degree of confidence in the Environmental Program.

Internal Quality Control checks and calibrations, traceable to U.S. or Canadian National Standards, are performed each work day and are routine for all analytical techniques in the Health Physics Environmental Laboratory.

All QA results obtained to date, show that the required degree of accuracy and precision is achieved.

The program is reviewed on an annual basis to ensure all objectives are being met.

7.2 Quality Control

The daily Quality Control (QC) evaluations in the laboratory cover the following instruments:

1. Canberra intrinsic Ge Gamma Spectrometer

2. Beckman Liquid Scintillation Counter

3. Tennelec LB-5100 Gross Alpha/Beta Detector

4. Panasonic UD-710A TLD Reader

In the QC program, the operating parameters of each of the major instruments are evaluated at the start of each working day. This ensures that they are consistent and remain free from significant drift or random variation that could influence the analyses. A compilation of the results and statistical fluctuations is maintained, and from these data the upper and lower flag limits are determined. If any equipment exceeds these limits, it is not used for any analytical work until the problem has been resolved.

Intrinsic Ge Gamma Spectrometer

A daily check of seven system parameters is performed for the germanium gamma spectrometry system. Measurements are made of the energy centroids, full width half maxima (FWHM) and efficiencies of two widely separated photon energies of Eu-152. These show the accuracy and precision of the system relative to the defined limits of acceptance. The rate of liquid nitrogen consumption is monitored to verify the physical integrity of the dewar. The results are processed by a computer program which generates QC plots and performs statistical tests to detect out-of-range values. A 200 000 s background count is made each weekend to ensure the absence of contamination in the sample chamber. The total counts in eight separate regions of the background spectrum are evaluated by the QC program, and out-of-range values are flagged for assessment.

Complete efficiency calibration on the gamma spectrometry system is checked annually for each of the counting geometries. This is accomplished using a mixed nuclide standard traceable to the U.S. National Institute of Standards and Technology (NIST).

Beckman Liquid Scintillation Counter (model LS6000 TA)

A set of sealed tritium, C-14 and background standards traceable to NIST is analysed daily. Statistical parameters must lie within defined limits or the equipment will not be used. These same standards are used to calibrate the instrument for each analysis run.

Tennelec LB-5100 Gross Alpha/Beta Detector

Planchet standards of Am-241 and Sr,Y-90 are analysed daily. Alpha and Beta discrimination allows the simultaneous analysis of alpha and beta emissions on all samples analysed. Planchet and filter backgrounds are included in the QC checks. These same standards are used to calibrate the instrument for each analysis run.

Panasonic UD-710A TLD Reader

A set of 16 TLDs is exposed in the Panarad Irradiator. The TLD reader is calibrated on an annual basis.

7.3 External Inter-comparison Programs

In addition to these in-house QC checks, the Health Physics Environmental Laboratory participates in inter-comparisons with other laboratories when programs are available.

Table 7.01 lists the various inter-comparison programs in which NB Power participates. These programs allow independent verification of the analytical performance of any of the participating laboratories.

Table 7.01
Quality Assurance Programs Involving Other Agencies

Sample Type	Analysis	Frequency	Agency*
Environmental Gamma radiation	TLD	Approx. every 2 years	U.S. DOE
Milk	Gamma	6 months	U.S. EPA
Fresh Water	Tritium I-131	4 months 6 months	U.S. EPA
Fresh Water	Tritium Carbon-14	undefined undefined	AECL
Milk	I-131	undefined	AECL
Food	various nuclides	undefined	AECL

* EPA U.S. Environmental Protection Agency.
DOE U.S. Department of Energy.
AECL Atomic Energy of Canada Limited.

7.4 Results of Inter-comparison Programs

Various inter-comparison programs were available this year. The EPA submitted samples for analysis, and some inter-comparison samples were provided by AECL, Chalk River. The results are tabulated below.

Table 7.02
Quality Assurance Program

Comparison of QA Agent, All Participants and NB Power

Analysis	Agent	Table No.	Sample Date	Ratio of Results NBPower/Agent	± 2 sigma range *All Participants
H-3	EPA	7.04	1998-03-13	0.84	0.78 - 1.22
		7.04	1998-08-07	0.92	0.86 - 1.13

* : Excluding those results significantly different from the population mean.

Table 7.03
EPA Gamma in Water
pCi/L ± 2 sigma

Analysis	Sample Date	EPA	*All Participants	NB Power	NBPower/EPA
I-131	1998-02-06	105 ± 15	106 ± 11	106 ± 15	1.01
	1998-09-11	6 ± 3	7 ± 2	6 ± 2	0.97

* : Excluding those results significantly different from the population mean.

Table 7.04
EPA Tritium in Water
pCi/L ± 2 sigma

Analysis	Sample Date	EPA	*All Participants	NB Power	NBPower/EPA
H-3	1998-03-13	2155 ± 492	2159 ± 468	1808 ± 186	0.84
	1998-08-07	17996 ± 2546	17874 ± 2378	16567 ± 444	0.92

* : Excluding those results significantly different from the population mean.

Table 7.05
AECL Vegetation
Bq/kg ± 2 sigma

Analysis	Sample Date	AECL	*All Participants	NB Power	NBPower/AECL
Ba-133	1998-01-01	102 ± 12	107 ± 12	101 ± 10	1.00
Co-60	1998-01-01	217 ± 12	234 ± 46	212 ± 11	0.98
Cs-134	1998-01-01	203 ± 11	218 ± 34	205 ± 17	1.01
Cs-137	1998-01-01	194 ± 14	203 ± 35	183 ± 12	0.94

* : Excluding those results significantly different from the population mean.

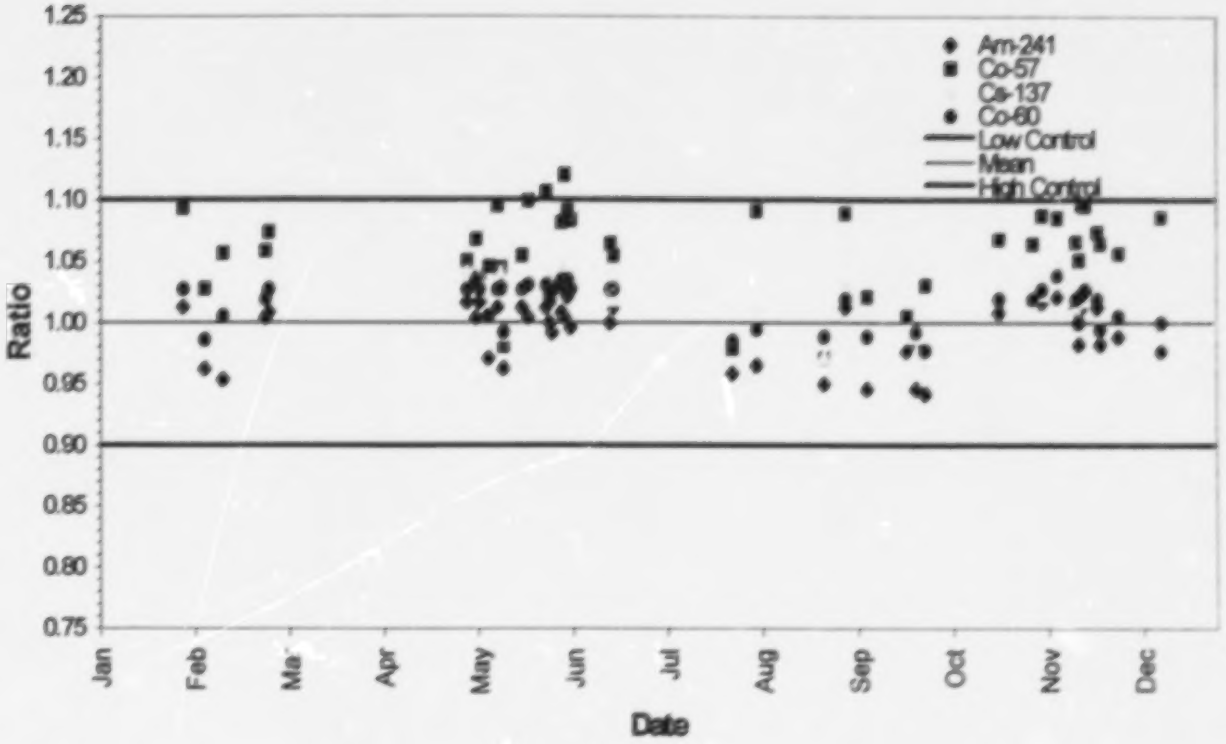


Figure 7.01
Repeated Analyses of Calibration Standards

7.5 Annual Review

A major review of the program takes place in January of each year. All members of the lab take part in this formal review which is approved by the Manager of Health Physics by the end of February. Generally, all aspects of the program are looked at to make sure that the objectives, as stated in this document, are being met. Major areas addressed are:

1) results (consistency and trends)
2) procedures (field and lab)
3) QA results
4) status of equipment
5) training of personnel
6) safety
7) emissions
8) meteorological data
9) Emergency Measures Organization data

As part of the annual review, the following considerations are re-evaluated:

- appropriateness of samples and sample stations
- redundancy of different environmental media (i.e. testing more media than necessary)
- frequency of sampling
- number of samples necessary

Throughout the year these same areas are addressed more informally at the lab meetings. Deficiencies observed are dealt with immediately.

Other areas that are addressed throughout the year as well as during the annual review are:

- high LLDs
- unexpected radionuclides
- unexpected levels of radionuclides
- daily QC biases & trends
- QA biases and trends
- errors in results

Deficiencies in these areas are dealt with promptly.

Appendices

Appendix A
Statistics, Detection Limits, and Dose at Detection Limits

A.1 Statistics

The following statistical conventions are applied in the analysis of each sample:

1. Detection limits are defined following the method described by Lochamy (NBS Special Publication 456 - Measurements for the Safe Use of Radiation, U.S. Department of Commerce, 1976). The Lower Limit of Detection (LLD) at the 99% confidence level is defined as 6.58 S_b, where S_b is the standard deviation of the appropriate, ill-defined, background measurement. Such an ill-defined background is typical of the germanium detector analyses, liquid scintillation analyses and alpha/beta determinations. This LLD corresponds to that amount of activity in a sample that will yield a net count greater than 3.29 S_b, i.e., the so-called Critical Level (CL), with 99% probability. The LLD specifies the theoretical capability of the system to quantify a given amount of radioactivity, whereas the CL is used to determine in practice whether a single activity measurement should be considered detected. Any individual measurement greater than 3.29 S_b is considered detected at the 99% confidence level. This also implies a 1% probability of stating that activity is present when it is not (false positive). If activity is present at the LLD level (6.58 S_b) there is a 1% probability of stating that activity is not present when it is (false negative). In most of the tables of data (Section 3.0), it is this Critical Level that appears in column 2. Where there are sufficient background data to provide a well defined background, as with the TLD data, the CL is defined as 2.33 S_b and the LLD as 4.66 S_b.

2. Unless otherwise indicated, the precision of the measurements reported here is given as ± 1.96 S_a (95% confidence level), where S_a is the standard deviation of the activity measurement.

3. The value and standard deviation are reported with two significant figures using modified scientific notation, for example 0.032 is expressed as 3.2E-02.

Airborne Particulates - Typical LLDs are given for a 2000 m^3 sample, counted for 5000 s. The LLDs are decay corrected to the midpoint between the start and end of sampling, except for the gross alpha/beta results which represent the long-lived activity present a few days after sample collection.

Airborne Radioiodines - A typical LLD for I-131 is 2E-04 Bq/m^3, (for a 2000 m^3 sample, counted for 50 000 s) which is decay corrected to the midpoint between the start and end of sampling.

Airborne Tritium - The LLD is approximately 1E-01 Bq/m^3 of air for a typical sample of 10 to 70 m^3 (counted for 100 min). Due to the long half-life and relatively short period of time between sampling and analysis, decay correction is not applied.

Airborne Carbon-14 - A typical LLD is about 7E-01 Bq/m^3 of air for a 30 m^3 sample (counted for 100 min). Due to the long half-life and relatively short period of time between sampling and analysis, decay correction is not applied.

TLD - The LLD is about 20 μSv. For typical quarterly measurements in the region of 150-200 μSv, measurements can be made to ± 10% at the 95% confidence level.

Table A.01
Annual Dose at the LLD for Air

NUCLIDE	*LLD (Bq/m^3)*	*Dose at LLD (μSv)*	*Activity That Gives 5 μSv (Bq/m^3)*
H-3	9.6E-02	4.8E-02	9.9E+00
C-14	6.8E-01	1.9E+00	1.8E+00
Cr-51	5.8E-04	3.2E-03	9.2E-01
Mn-54	7.8E-05	9.2E-02	4.3E-03
Fe-59	1.7E-04	6.1E-02	1.4E-02
Co-58	8.0E-05	3.5E-02	1.2E-02
Co-60	8.2E-05	1.7E+00	2.4E-04
Zn-65	1.9E-04	3.3E-01	2.9E-03
Kr-85	2.0E+01μSv	2.0E+01	5.0E+00 μSv
Kr-85m	2.0E+01μSv	2.0E+01	5.0E+00 μSv
Kr-87	2.0E+01μSv	2.0E+01	5.0E+00 μSv
Kr-88	2.0E+01μSv	2.0E+01	5.0E+00 μSv
Zr-95	1.3E-04	1.1E-01	6.2E-03
Nb-95	9.4E-05	9.9E-02	4.7E-03
Ru-103	7.4E-05	8.1E-03	4.5E-02
Ru-106	6.0E-04	1.0E+00	2.9E-03
Ag-110m	6.2E-05	2.2E-01	1.4E-03
I-131	1.8E-04	3.5E-01	2.5E-03
Xe-131m	2.0E+01μSv	2.0E+01	5.0E+00 μSv
Xe-133	2.0E+01μSv	2.0E+01	5.0E+00 μSv
Xe-133m	2.0E+01μSv	2.0E+01	5.0E+00 μSv
Xe-135	2.0E+01μSv	2.0E+01	5.0E+00 μSv
Xe-135m	2.0E+01μSv	2.0E+01	5.0E+00 μSv
Xe-138	2.0E+01μSv	2.0E+01	5.0E+00 μSv
Cs-134	6.4E-05	4.3E-01	7.4E-04
Cs-137	6.6E-05	1.6E+00	2.0E-04
Ba-140	4.8E-04	8.9E-02	2.7E-02
La-140	2.0E-04	2.5E-03	4.1E-01
Ce-141	7.6E-05	4.8E-03	7.9E-02
Ce-144	2.2E-04	2.7E-01	4.0E-03
Noble Gases	2.0E+01μSv	2.0E+01	5.0E+00 μSv
gross Alpha	6.6E-06		
gross Beta	1.7E-05		

The Annual Dose is to a member of the Critical Group. The LLD is based on typical data from 1998. Since a new method of carbon-14 analyses will be instituted with the revised program, this LLD will decrease. Decay of radionuclides is accounted for in the LLD. The major assumptions are that the sample is taken at one kilometre from the point of emissions and that the level is maintained for the year. As part of the QA process, any sample whose LLD or result exceeds the 5 μSv target will be investigated.

Milk - Typical LLDs for the nuclides of interest in milk (a 3.6 L sample counted for 50 000 s for gamma; 6.0 mL sample counted for 100 min for tritium) are listed for the time of sample collection.

Table A.02
Annual Dose at the LLD for Milk

NUCLIDE	LLD (Bq/L)	Dose at LLD (μSv)	Activity That Gives 5 μSv (Bq/L)
H-3	2.4E+01	3.1E-01	3.9E+02
Cr-51	6.4E-01	1.0E-02	3.1E+02
Mn-54	9.2E-02	1.9E-02	2.5E+01
Fe-59	2.2E-01	2.2E-01	5.1E+00
Co-58	9.0E-02	7.5E-02	6.0E+00
Co-60	1.1E-01	9.0E-01	6.1E-01
Zn-65	2.4E-01	5.3E-01	2.3E+00
Zr-95	1.6E-01	4.3E-02	1.8E+01
Nb-95	9.2E-02	1.2E-01	3.8E+00
Ru-103	8.4E-02	1.9E-02	2.2E+01
Ru-106	7.8E-01	2.7E+00	1.4E+00
Ag-110m	8.2E-02	5.5E-02	7.4E+00
I-131	9.4E-02	1.8E+00	2.6E-01
Cs-134	7.8E-02	3.1E-01	1.3E+00
Cs-137	9.8E-02	3.1E-01	1.6E+00
Ba-140	3.4E-01	2.1E-01	8.1E+00
La-140	1.1E-01	8.9E-02	6.1E+00
Ce-141	1.2E-01	3.0E-02	2.1E+01
Ce-144	5.0E-01	9.5E-01	2.6E+00

The Annual Dose is to a member of the Critical Group. The LLD is based on typical data from 1998. Decay of radionuclides is accounted for in the LLD. The major assumptions are that the sample is taken at 1.5 km from the point of emissions and that the level is maintained for the year. As part of the QA process, any sample whose LLD

or result exceeds the 5 μSv target will be investigated.

Water - The following LLDs apply to the time of sample collection for a 3.6 L sample counted for 5000 s for gamma and a 6.0 mL sampled counted for 100 min for tritium. Alpha/beta results (a 200 mL sample counted for 100 min) represent the long-lived activity present several days after sample collection.

Table A.03
Annual Dose at the LLD for Water

NUCLIDE	LLD (Bq/L)	Dose at LLD (μSv)	Activity That Gives 5 μSv (Bq/L)
H-3	2.4E+01	3.4E-01	3.6E+02
Cr-51	5.4E+01	7.4E-02	3.7E+03
Mn-54	5.0E-01	1.7E-01	1.4E+01
Fe-59	1.3E+00	9.1E-01	7.1E+00
Co-58	5.6E-01	3.7E-01	7.5E+00
Co-60	4.6E-01	4.5E+00	5.1E-01
Zn-65	1.1E+00	2.3E+00	2.4E+00
Zr-95	9.8E-01	4.0E-01	1.2E+01
Nb-95	6.8E-01	4.0E-01	8.5E+00
Ru-103	6.4E-01	1.8E-01	1.8E+01
Ru-106	4.6E+00	1.7E+01	1.4E+00
Ag-110m	4.6E-01	6.2E-01	3.7E+00
I-131	2.4E+00	3.9E+00	3.1E+00
Cs-134	4.4E-01	4.8E+00	4.6E-01
Cs-137	5.2E-01	3.9E+00	6.6E-01
Ba-140	5.4E+00	2.7E+00	1.0E+01
La-140	2.2E+00	9.1E-01	1.2E+01
Ce-141	8.4E-01	3.4E-01	1.2E+01
Ce-144	2.4E+00	1.1E+01	1.1E+00
gross Alpha	1.2E-01		
gross Beta	8.4E-02		

The Annual Dose is to a member of the Critical Group. The LLD is based on typical data for rainwater from 1998 (the only water sample that has significant decay before analysis). Since decay of radionuclides is accounted for in the LLD, Well Water and other water sample types will have lower LLDs than this. The major assumptions are that the sample is taken at one kilometre from the point of emissions, that the level is maintained for the year and the sample type is the major source of drinking water.

Obviously this is not the case but it gives a simple "worst case" that is easy to monitor and calculate

Food - The following LLDs apply to the time of sample collection. Samples are counted for 5000 s (size varies).

Table A.04
Annual Dose at the LLD for Food

NUCLIDE	LLD (Bq/kg)	Dose at LLD (μSv)	Activity That Gives 5 μSv (Bq/kg)
Cr-51	3.0E+01	5.9E-02	2.5E+03
Mn-54	3.4E+00	1.3E-01	1.3E+02
Fe-59	7.8E+00	8.4E-01	4.6E+01
Co-58	3.6E+00	3.0E-01	6.0E+01
Co-60	3.8E+00	3.9E+00	4.9E+00
Zn-65	9.0E+00	2.2E+00	2.1E+01
Zr-95	6.2E+00	3.3E-01	9.4E+01
Nb-95	4.0E+00	3.6E-01	5.6E+01
Ru-103	3.8E+00	1.7E-01	1.1E+02
Ru-106	3.0E+01	1.3E+01	1.1E+01
Ag-110m	3.0E+00	4.7E-01	3.2E+01
I-131	1.0E+01	6.9E+00	7.6E+00
Cs-134	3.0E+00	3.6E+00	4.2E+00
Cs-137	3.4E+00	2.9E+00	6.0E+00
Ba-140	2.4E+01	3.5E+00	3.5E+01
La-140	9.4E+00	1.2E+00	4.0E+01
Ce-141	4.2E+00	1.9E-01	1.1E+02
Ce-144	1.4E+01	4.9E+00	1.4E+01

The Annual Dose is to a member of the Critical Group. The LLD is based on typical data for garden vegetables from 1998 (the only food sample that has significant decay before analysis). Since decay of radionuclides is accounted for in the LLD, Berries and other food sample types will have lower LLDs than this. The major assumptions are that the sample is taken at one kilometre from the point of emissions and that the level is maintained for the year. As part of the QA process, any sample whose LLD or result exceeds the 5 μSv target will be investigated.

Soil - The following LLDs apply to the time of sample collection. Approximately 200 g samples are counted for 5000 s.

Table A.05
Annual Dose at the LLD for Soil

NUCLIDE	LLD (Bq/kg)	Dose at LLD (μSv)	Activity That Gives 5 μSv (Bq/kg)
Cr-51	4.0E+01	2.5E-01	7.9E+02
Mn-54	5.8E+00	1.2E+00	2.5E+01
Fe-59	1.2E+01	3.1E+00	1.9E+01
Co-58	5.0E+00	1.1E+00	2.2E+01
Co-60	5.8E+00	3.2E+00	9.1E+00
Zn-65	1.3E+01	1.7E+00	3.9E+01
Zr-95	1.0E+01	5.1E+00	9.9E+00
Nb-95	6.0E+00	9.9E-01	3.0E+01
Ru-103	4.8E+00	5.1E-01	4.7E+01
Ru-106	4.6E+01	1.9E+00	1.2E+02
Ag-110m	5.2E+00	2.7E+00	9.7E+00
I-131	6.8E+00	5.2E-01	6.6E+01
Cs-134	5.2E+00	1.5E+00	1.7E+01
Cs-137	5.6E+00	7.1E-01	3.9E+01
Ba-140	2.2E+01	1.1E+01	9.6E+00
La-140	7.2E+00	*	*
Ce-141	6.8E+00	1.2E-01	2.8E+02
Ce-144	2.4E+01	2.9E-01	4.2E+02
TLD	2.0E+01	2.0E+01	5.0E+00

*Dose for Ba-140 assumes equilibrium with La-140 (contribution from both)

The Annual Dose is to a member of the Critical Group. The LLD is based on typical data from 1998. Decay of radionuclides is accounted for in the LLD. The major assumptions are that the sample is taken at one kilometre from the point of emissions and that the level is maintained for the year.

Seawater - The following LLDs apply to the time of sample collection (for a 3.6 L sample counted for 5000 s; a 6.0 mL sampled counted for 100 min for tritium).

Table A.06
Annual Dose at the LLD for Seawater

NUCLIDE	LLD (Bq/L)	Dose at LLD (μSv)	Activity That Gives 5 μSv (Bq/L)
H-3	2.4E+01	9.2E-11	1.3E+12
Cr-51	2.2E+00	2.6E-10	4.3E+10
Mn-54	2.8E-01	7.9E-10	1.8E+09
Fe-59	6.2E-01	2.6E-09	1.2E+09
Co-58	2.8E-01	9.1E-10	1.5E+09
Co-60	3.2E-01	2.4E-09	6.8E+08
Zn-65	6.8E-01	1.3E-09	2.6E+09
Zr-95	5.2E-01	1.2E-09	2.2E+09
Nb-95	3.0E-01	9.3E-10	1.6E+09
Ru-103	2.8E-01	4.4E-10	3.2E+09
Ru-106	2.6E+00	1.6E-09	8.3E+09
Ag-110m	2.6E-01	2.3E-09	5.7E+08
I-131	3.6E-01	2.3E-09	8.0E+08
Cs-134	2.6E-01	1.3E-09	1.0E+09
Cs-137	3.0E-01	5.2E-10	2.9E+09
Ba-140	1.2E+00	2.6E-08	2.4E+08
La-140	4.6E-01	*	*
Ce-141	4.0E-01	1.1E-10	1.8E+10
Ce-144	1.6E+00	2.7E-10	3.0E+10

* Dose for Ba-140 assumes equilibrium with La-140 (contribution from both)

The Annual Dose is to a member of the Critical Group. The LLD is based on typical data from 1998. Decay of radionuclides is accounted for in the LLD. The major assumptions are that the sample is taken at one kilometre from the point of emissions and that the level is maintained for the year. The dose is small due to the simple facts that the Bay of Fundy is frigid at the best of times (occupancy factor is low) and no one drinks salt water.

Clams - Typical LLDs are given for the edible portions of clams decay corrected to the time of sample collection. Samples are counted for 5000 s (size varies).

Table A.07
Annual Dose at the LLD for Clams

NUCLIDE	LLD (Bq/kg)	Dose at LLD (μSv)	Activity That Gives 5 μSv (Bq/kg)
Cr-51	5.0E+01	2.0E-02	1.3E+04
Mn-54	7.0E+00	6.5E-02	5.4E+02
Fe-59	1.4E+01	3.1E-01	2.3E+02
Co-58	7.2E+00	1.3E-01	2.7E+02
Co-60	6.4E+00	1.8E+00	1.8E+01
Zn-65	1.4E+01	8.8E-01	7.8E+01
Zr-95	1.2E+01	1.5E-01	3.7E+02
Nb-95	6.6E+00	1.4E-01	2.3E+02
Ru-103	6.0E+00	5.5E-02	5.5E+02
Ru-106	5.8E+01	6.5E+00	4.5E+01
Ag-110m	5.8E+00	2.2E-01	1.3E+02
I-131	7.2E+00	9.5E-01	3.8E+01
Cs-134	6.6E+00	1.6E+00	2.1E+01
Cs-137	6.8E+00	1.5E+00	2.2E+01
Ba-140	2.4E+01	7.7E-01	1.6E+02
La-140	9.4E+00	2.2E-01	2.1E+02
Ce-141	7.4E+00	8.0E-02	4.6E+02
Ce-144	3.2E+01	2.6E+00	6.3E+01

The Annual Dose is to a member of the Critical Group. The LLD is based on typical data from 1998. Decay of radionuclides is accounted for in the LLD. The major assumptions are that the sample is taken at Dipper Harbour and that the level is maintained for the year

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Fish - Typical LLDs are given for the edible portions of fish decay corrected to the time of sample collection. Samples are counted for 5000 s (size varies).

Table A.08
Annual Dose at the LLD for Fish

NUCLIDE	LLD (Bq/kg)	Dose at LLD (μSv)	Activity That Gives 5 μSv (Bq/kg)
Cr-51	1.3E+01	1.6E-02	4.0E+03
Mn-54	1.5E+00	5.1E-02	1.5E+02
Fe-59	3.8E+00	2.8E-01	6.8E+01
Co-58	1.5E+00	9.2E-02	8.0E+01
Co-60	1.4E+00	1.3E+00	5.4E+00
Zn-65	3.0E+00	7.0E-01	2.2E+01
Zr-95	2.2E+00	1.1E-01	1.0E+02
Nb-95	1.4E+00	1.1E-01	6.6E+01
Ru-103	1.5E+00	4.9E-02	1.5E+02
Ru-106	1.1E+01	4.4E+00	1.2E+01
Ag-110m	1.2E+00	1.7E-01	3.5E+01
I-131	7.8E+00	1.3E+00	3.1E+01
Cs-134	1.0E+00	1.2E+00	4.5E+00
Cs-137	1.4E+00	1.0E+00	7.1E+00
Ba-140	1.0E+01	7.8E-01	6.4E+01
La-140	4.6E+00	2.4E-01	9.6E+01
Ce-141	1.8E+00	6.0E-02	1.5E+02
Ce-144	5.8E+00	1.6E+00	1.8E+01

The Annual Dose is to a member of the Critical Group. The LLD is based on typical data from 1998. Decay of radionuclides is accounted for in the LLD. The major assumptions are that the sample is taken at the point of emissions and that the level is maintained for the year.

Lobster - Typical LLDs are given for the edible portions of lobster decay corrected to the time of sample collection. Samples are counted for 5000 s (size varies)

Table A.09
Annual Dose at the LLD for Lobster

NUCLIDE	LLD (Bq/kg)	Dose at LLD (μSv)	Activity That Gives 5 μSv (Bq/kg)
Cr-51	3.0E+01	1.3E-02	1.2E+04
Mn-54	2.8E+00	2.1E-02	6.7E+02
Fe-59	9.0E+00	1.5E-01	2.9E+02
Co-58	3.2E+00	6.7E-02	2.4E+02
Co-60	3.8E+00	5.4E-01	3.5E+01
Zn-65	7.8E+00	3.4E-01	1.2E+02
Zr-95	5.4E+00	6.8E-02	4.0E+02
Nb-95	4.4E+00	9.0E-02	2.4E+02
Ru-103	4.0E+00	3.1E-02	6.4E+02
Ru-106	3.0E+01	2.4E+00	6.3E+01
Ag-110m	3.4E+00	8.8E-02	1.9E+02
I-131	1.7E+01	3.3E+00	2.6E+01
Cs-134	2.8E+00	6.4E-01	2.2E+01
Cs-137	3.4E+00	4.5E-01	3.8E+01
Ba-140	3.4E+01	1.2E+00	1.4E+02
La-140	1.2E+01	4.2E-01	1.4E+02
Ce-141	4.4E+00	4.3E-02	5.1E+02
Ce-144	1.3E+01	8.7E-01	7.4E+01

The Annual Dose is to a member of the Critical Group. The LLD is based on typical data from 1998. Decay of radionuclides is accounted for in the LLD. The major assumptions are that the sample is taken at the point of emissions and that the level is maintained for the year.

Dulse - Typical LLDs are given for dulse decay corrected to the time of sample collection. Samples are counted for 5000 s (size varies).

Table A.10
Annual Dose at the LLD for Dulse

NUCLIDE	LLD (Bq/kg)	Dose at LLD (μSv)	Activity That Gives 5 μSv (Bq/kg)
Cr-51	2.0E+01	2.4E-03	4.2E+04
Mn-54	3.4E+00	7.4E-03	2.3E+03
Fe-59	8.0E+00	4.4E-02	9.0E+02
Co-58	3.4E+00	1.5E-02	1.1E+03
Co-60	3.4E+00	2.1E-01	7.9E+01
Zn-65	8.2E+00	1.1E-01	3.9E+02
Zr-95	6.6E+00	1.6E-02	2.1E+03
Nb-95	3.6E+00	1.9E-02	9.5E+02
Ru-103	2.8E+00	7.1E-03	2.0E+03
Ru-106	2.6E+01	6.7E-01	2.0E+02
Ag-110m	3.0E+00	2.3E-02	6.4E+02
I-131	5.4E+00	3.0E-01	9.1E+01
Cs-134	2.8E+00	1.9E-01	7.3E+01
Cs-137	3.2E+00	1.3E-01	1.2E+02
Ba-140	1.6E+01	1.6E-01	4.9E+02
La-140	5.4E+00	2.8E-02	9.7E+02
Ce-141	3.4E+00	8.8E-03	1.9E+03
Ce-144	1.4E+01	2.4E-01	2.9E+02

The Annual Dose is to a member of the Critical Group. The LLD is based on typical data from 1998. Decay of radionuclides is accounted for in the LLD. The major assumptions are that the sample is taken at Dipper Harbour and that the level is maintained for the year.

Sediment - The following LLDs apply to the time of sample collection. Approximately 200 g samples are counted for 5000 s.

Table A.11
Annual Dose at the LLD for Sediments

NUCLIDE	LLD (Bq/kg)	Dose at LLD (μSv)	Activity That Gives 5 μSv (Bq/kg)
Cr-51	1.7E+01	2.1E-01	4.2E+02
Mn-54	2.8E+00	7.9E-01	1.8E+01
Fe-59	6.2E+00	2.3E+00	1.3E+01
Co-58	2.6E+00	8.4E-01	1.5E+01
Co-60	2.8E+00	2.3E+00	6.1E+00
Zn-65	6.8E+00	1.3E+00	2.7E+01
Zr-95	4.8E+00	3.9E+00	6.1E+00
Nb-95	3.0E+00	7.2E-01	2.1E+01
Ru-103	2.4E+00	3.9E-01	3.1E+01
Ru-106	2.0E+01	1.5E+00	6.6E+01
Ag-110m	2.2E+00	2.1E+00	5.3E+00
I-131	3.4E+00	4.7E-01	3.6E+01
Cs-134	2.0E+00	1.2E+00	8.7E+00
Cs-137	2.8E+00	6.2E-01	2.3E+01
Ba-140	1.2E+01	1.0E+01	5.8E+00
La-140	3.8E+00	*	*
Ce-141	3.0E+00	8.9E-02	1.7E+02
Ce-144	1.1E+01	2.1E-01	2.7E+02
gamma meter	0.01 μSv/h	3.0E+00	1.7E-02

* Dose for Ba-140 assumes equilibrium with La-140 (contribution from both)

The Annual Dose is to a member of the Critical Group. The LLD is based on typical data from 1998. Decay of radionuclides is accounted for in the LLD. The major assumptions are that the sample is taken at Dipper Harbour and that the level is maintained for the year.

Appendix B
Sample Collection and Analytical Techniques

B.1 Analytical Techniques

The major analytical techniques and the instruments used in routine environmental analysis are summarised in Table 8.01. In gamma spectrometry analysis, all significant peaks in the spectrum are identified either by reference to a database library of about 150 radionuclides, or by manual reference to compilations of all known radionuclides. In addition, approximately 20 selected radionuclides are specifically searched for in every sample with the exception of Air Iodine samples in which only I-131 is selected. The selected radionuclides include those which are produced in PLGS and which would be readily detectable because of their abundance (high fission yield) and high branching ratios for gamma emissions. Naturally occurring gamma emitters, with the exception of Be-7, K-40 and Ac-228, are not included in this report. These excepted radionuclides are sometimes useful as general indicators of the consistency of the analytical techniques.

The new peak search and analysis program SAMPO is used to process spectra. The library of radionuclides uses data of the Oak Ridge Laboratory. There are three categories of radionuclides evaluated:

- selected nuclides of key fission and activation products
- all other identified radionuclides, including natural radionuclides
- detected energy peaks for which no identification can be readily made.

The three categories cover all possible eventualities in a spectral analysis and ensure that no significant radionuclides or photon energies will be missed.

The usefulness of gross alpha/beta analysis lies primarily in screening samples to determine whether more detailed analyses should be performed. The reported alpha and beta values are assessed with respect to Am-241 and Sr-Y-90 calibration sources, respectively.

Wet chemical analyses for Sr-90 on Gaseous Effluent Monitoring (GEM) and Liquid Effluent Monitoring (LEM) samples indicated that emissions are generally below the limit of detection.

Table B.01
Summary Of Analytical Techniques

Analytical Technique	Instrumentation
Gamma Spectrometry	A Canberra 24% efficient ** intrinsic germanium detector, in an Applied Physical Technology 10 cm graded lead cave. A NaI(7.6 x 7.6 cm) detector in Canberra S100 multichannel analyser. PC for automatic data reduction.
Liquid Scintillation (Tritium and C-14)	Beckman LS-6000TA analyser.
Gross Alpha/Beta and Sr-90 Analyses	Tennelec LB-5100 Alpha/Beta counter.
Thermoluminescence Dosimetry	Panasonic UD-710A Automatic TLD Reader and UD-814AS1 ($CaSO_4$) dosimeters.
Chemical analysis	Laboratory separation and analysis for Sr-90 on various sample types. The final analysis is by Tennelec alpha/beta counting.

** relative to a 3 x 3 inch sodium iodide detector.

B.2 Sample Collection, Analysis And Detection Limits

Airborne Particulates

Collection

Airborne particulates are collected on a 47 mm diameter Gelman Type A glass fibre filter through which air is drawn at about 60 L/min (approximately 2400 m^3 for a 28 day continuous sample). The volume of air sampled is measured with an in-line integrating dry gas meter. Every month the filters are replaced and the used ones are returned to the

laboratory for analysis. Sampling is therefore continuous throughout the year, the only interruption (other than power failure or pump breakdown) being the few minutes for a filter change. Less than about 4% of collection time was lost due to breakdown and electrical power failures in 1998.

Analysis

Air particulate filters are analysed by gamma spectrometry as soon as possible after collection to minimize loss of information through radioactive decay (ensure detection of any short lived gamma emitters that may be present, and to minimise any decay corrections). Samples are counted for 5000 s on the Ge detector.

Approximately three days after the end of the sample collection interval, each filter is counted for 100 minutes for the simultaneous determination of gross alpha and gross beta activity. Counting is delayed to allow for the decay of the short-lived radon progeny which would otherwise complicate the analysis.

Airborne Radioiodine

Collection

Airborne radioiodine is collected in an activated charcoal cartridge placed downstream of the particulate filter. The cartridges are Nuclear Consulting Services NUSORB (47 mm diameter and 48 mm length) containing 5% TEDA by weight. For a 28 day continuous sample approximately 2400 m^3 of air is sampled at a flow rate of about 60 L/min. The volume of air sampled is measured with an in-line integrating dry gas meter. The charcoal used in these cartridges is made from coconut fibre contains traces of Cs-137 from bomb test fallout.

Analysis

Iodine-131 is the major nuclide of interest on the charcoal cartridges. The cartridges are counted in groups of four for 50 000 s on the gamma spectrometer. Counts are performed as soon as possible after collection because of the relatively short-half life of I-131 (8 days). If radioiodine is detected above the LLD for a 5 000 s count on a single cartridge, then the cartridges are re-analysed individually. Other fission product radioiodines, with much shorter half lives (minutes to hours), decay before they reach the sample location or during the time the sample is being collected. If a significant release of radioiodine were noted from the station in this interval, the samples would be changed and analysed earlier to minimise errors from decay corrections.

Airborne Tritium

Collection

A fraction of the flow in the air monitoring sample train is diverted through a molecular sieve container where water vapour is trapped. The volume of air passed through the molecular sieve is measured with an in-line integrating dry gas meter. The sieve material is later heated to 450°C to drive off absorbed water which is then condensed and collected for analysis. Sampling is continuous at each location throughout the year, but is interrupted for a few minutes every month to exchange sieve containers. Since the amount of water, absorbed by the molecular sieve from a given volume of air depends upon absolute humidity, flow rates are adjusted seasonally (using a Dwyer flow meter) to avoid saturation of the sieve material and to ensure adequate sample collection.

Analysis

For tritium analysis by liquid scintillation counting, 6 mL of water taken from the molecular sieve condensate is mixed with 15 mL of Aquasol-II, and counted for 100 minutes.

Airborne Carbon-14

Collection

Airborne carbon dioxide is collected in a 1 L volume of 2N caustic soda solution at three environmental monitoring locations: lighthouse (G02), Duck Cove (H04) and in the laboratory in Fredericton (X03R). The volume of air sampled is assessed by gravimetric analysis of the dissolved carbon dioxide precipitated from solution as barium carbonate. A new method of collection and analysis using "Carbosorb E" is being evaluated as a means of improving detection sensitivity.

Analysis

Carbon-14 is determined by liquid scintillation analysis of a 4 mL aliquot of the solution in 15 mL of "Hionic Fluor".

Environmental Gamma Radiation

Thermoluminescence Dosimetry (TLD)

Environmental gamma radiation is measured by thermoluminescence dosimetry for each of 65 locations. All locations are changed each quarter year and the TLDs returned to the laboratory for readout.

The TLD phosphor is contained in a holder comprising three elements of lead-filtered

calcium sulphate and one of lithium borate. The individual TLDs are placed in screw cap plastic containers and suspended about 1 m above the ground. All natural background radiation measurements are considerably higher than the LLD. The expected precision is about ± 10% at the 95% confidence level.

Environmental Dose Rate Survey Measurements

Gamma dose rate measurements (beach surveys) are taken quarterly on the inter-tidal area of beaches and mud flats in the Point Lepreau area with an environmental gamma survey meter (Eberline Model FH 40G-10 low range gamma survey meter with a range of 10 nSv/h to 1 Sv/h for 30 keV to 3 MeV photons). In these inter-tidal locations it is impracticable to use TLDs.

Sediment

Collection and preparation

Inter-tidal sediments (sand, silt and clay) are collected near the low tide mark, with preference being given to the top 50 mm of the finely-divided silts characteristic of tidal mud flats. Disposable polyethylene containers are used to collect about 2 kg of sample which is later transferred to disposable aluminum trays for drying. Dried caked samples are broken into their original free granular form with a porcelain mortar and pestle, and sieved through a 0.2 mm mesh to collect the fines for analysis (a 1 mm sieve is used for coarse sediments).

Analysis

Approximately 0.25 kg of dried sediment is counted for 5000 s on the gamma spectrometry system.

Soil

Soil samples are collected in undisturbed locations away from nearby buildings or trees. Level areas with some vegetation are preferred. A representative sample (approximately 1 kg) of the top 10 mm of soil is collected using a soil sampler, and placed in a disposable polyethylene container.The soil is dried and sifted through a 0.5 mm sieve in the laboratory.

Analysis

Approximately 0.25 kg of dried soil is counted for 5000 s on the gamma spectrometry system.

Water (Well Water/Sea Water)

Collection and Preparation

A 4 L sample of well water or sea water is collected, placed in a disposable polyethylene container.and acidified with 15 mL of concentrated nitric acid. About 20 mL of each sample, taken out before acidification, is used for tritium analysis. Well water samples (125-500 mL, depending upon the dissolved solids content) are evaporated to dryness on stainless steel planchets for gross alpha/beta analysis. Measurements of gross alpha and beta are made about two weeks after sample collection. This delay avoids analytical interference from radon progeny whose activity is tied to that of the parent, which decays with a half life of about 3.8 days. Natural radon and radon progeny occur in well waters everywhere and are known to reach high concentrations in many New Brunswick locations.

Other water samples collected and analysed include those at the SRWMF (Phase 1 and 2), i.e., Bore Hole waters and surface run-off collected in the Parshall Flumes.

Analysis

For gross alpha/beta analysis of well water, dried samples are counted for 100 minutes on a Tennelec LB-5100 Alpha/Beta counting system. For tritium analysis, a 6 mL sample of fresh water or sea water (optionally distilled) is mixed with 15 mL of Aquasol-II and counted for 100 minutes by liquid scintillation. For gamma spectrometry analysis, a 3.6 L sample is counted for 5000 s on the gamma spectrometer.

Milk

Collection

A 4 L sample of milk is collected for gamma spectrometric analysis and, if necessary, preserved by the addition of 15 mL of a 37% formaldehyde solution. Distillate from an aliquot of the same sample, before the addition of preservative, is used for tritium analysis.

Analysis

For tritium analysis by liquid scintillation counting, a 6 mL sample of distillate is mixed with 15 mL of Aquasol-II and counted for 100 minutes. For gamma spectrometric analysis, a 3.6 L sample is analysed for 50 000 s (overnight).

Seafood

Collection and Preparation

Approximately 0.5 to 2 kg of fresh seafood is collected for analysis as available. The lobsters are cooked before analysis to facilitate removal of the meat. Whole, uncooked periwinkles, clams, crabs and mussels are analysed, but the analysis is attributed only to the flesh weight of the sample (about 15-25% of the total). Dulse (*Rhodymenia palmata*) is the most commonly harvested edible seaweed in the Point Lepreau area. Other species of seaweed, e.g., *Laminaria* and *Ascophylum*, have been examined for their commercial possibilities, but they are not currently harvested.

Analysis and Detection Limits

Approximately 0.25 kg of each prepared sample is counted for 5000 s.

Vegetation

Collection and Preparation

The only vegetation types routinely collected and analysed are tree lichen (Spanish moss) and various ground mosses such as *Cladonia* and *Lycopodium*. About 50 g or more of each of the samples is collected and air dried before analysis. No special preparation is required. Reference samples are collected from the Fredericton area.

Analysis

Samples are counted for 5000 s on a gamma spectrometer.

Garden Vegetables

Collection and Preparation

Vegetables (about 250 g or more) from local gardens are collected during the short growing season. No special preparation is required.

Analysis

Samples are counted for 5000 s on a gamma spectrometer.

Berries

Collection and Preparation

Berries (about 250 g or more from the commercial blueberry fields in Pennfield) are collected during the short growing season. Occassionally other varieties are collected from residents or in the wild on the Lepreau peninsula. No special preparation is required.

Analysis

Samples are counted for 5000 s on a gamma spectrometer.

Appendix C
Location Codes

A 5m	PLGS Dry Fuel Storage Facility -5 m NNE from perimeter fence
A 10m	PLGS Dry Fuel Storage Facility -10 m NNE from perimeter fence
A 15m	PLGS Dry Fuel Storage Facility -15 m NNE from perimeter fence
A 20m	PLGS Dry Fuel Storage Facility -20 m NNE from perimeter fence
A 25m	PLGS Dry Fuel Storage Facility -25 m NNE from perimeter fence
A 50m	PLGS Dry Fuel Storage Facility -50 m NNE from perimeter fence
A 75m	PLGS Dry Fuel Storage Facility -75 m NNE from perimeter fence
A 100m	PLGS Dry Fuel Storage Facility -100 m NNE from perimeter fence
A 118m	PLGS Dry Fuel Storage Facility -118 m NNE from perimeter fence
A01R	Bocabec –Barry & Michelle Schriver
A02R	Bocabec -field across from A01R
A03R	Bocabec -intertidal zone
A04	Bayside -Alexander Muir (Fairmile Farm)
A05R	Letete
A06	Digdeguash
A07	Beaver Harbour
A08	Back Bay
A09	Chamcook
A10R	Grand Manan
A11	Oak Bay / Waweig
B 5m	PLGS Dry Fuel Storage Facility -5 m WNW from perimeter fence
B 10m	PLGS Dry Fuel Storage Facility -10 m WNW from perimeter fence
B 15m	PLGS Dry Fuel Storage Facility -15 m WNW from perimeter fence
B 20m	PLGS Dry Fuel Storage Facility -20 m WNW from perimeter fence
B 25m	PLGS Dry Fuel Storage Facility -25 m WNW from perimeter fence
B 50m	PLGS Dry Fuel Storage Facility -50 m WNW from perimeter fence
B 75m	PLGS Dry Fuel Storage Facility -75 m WNW from perimeter fence
B 100m	PLGS Dry Fuel Storage Facility -100 m WNW from perimeter fence
B 150m	PLGS Dry Fuel Storage Facility -150 m WNW from perimeter fence
B 200m	PLGS Dry Fuel Storage Facility -200 m WNW from perimeter fence
B01	New River Beach -intertidal zone
B02	Pocologan
B03	New River Beach -park
B04	New River Harbour to Pocologan Harbour
B10	Pennfield
BAXR	Baxter's Dairy
BB	PLGS -Boiler Blowdown
BD	Belledune GS
C01	Lepreau Harbour -intertidal zone
C03	Lepreau
CCW	PLGS -Condenser Cooling Water
CH	Chatham GS
D01	Little Lepreau Basin -intertidal zone (remnants of clam shack)
D02	Little Lepreau
D03	Little Lepreau -Chester McPherson
D04	Little Lepreau Basin -intertidal zone (remnants of boat wreck)
DH	Dalhousie GS
DUMP	PLGS –onsite landfill
DWC	PLGS -drinking water fountains
E01	Maces Bay -Floyd Small
E02	Maces Bay -Fundy Senior Citizens Centre
E03	Maces Bay -intertidal zone
E04	Maces Bay Cemetery
E05	Fundy Shores Elementary School -outside

E06	Fundy Shores Elementary School -inside
EPA	US Environmental Protection Agency
F01	Welch Cove -Dave Wright
F02	Welch Cove -intertidal zone
G01	Indian Cove -intertidal zone
G02	Point Lepreau -lighthouse
G03	offshore -within 2 km of Point Lepreau lighthouse
G04	Point Lepreau -intertidal zone south of PLGS condenser cooling water outfall
GEM	PLGS -Gaseous Effluent monitor
GL	Grand Lake GS
H01	Duck Cove -duck pond
H02	offshore -close to PLGS condenser cooling water outfall
H03	Duck Cove -intertidal zone
H04	PLGS -across the road from old site of Information Centre building
H05	PLGS -start of nature trail near old site of Information Centre public display trailers
HS	Hanson Stream Reservoir
I00	PLGS Solid Radioactive Waste Management Facility -general site area
I00A	PLGS Solid Radioactive Waste Management Facility -south fence (east side) / Bore Hole A
I00B	PLGS Solid Radioactive Waste Management Facility -south fence (centre) / Bore Hole B
I00C	PLGS Solid Radioactive Waste Management Facility -south fence (west side) / Bore Hole C
I00D	PLGS Solid Radioactive Waste Management Facility -west fence (south side)
I00E	PLGS Solid Radioactive Waste Management Facility -west fence (centre)
I00F	PLGS Solid Radioactive Waste Management Facility -west fence (north side)
I00G	PLGS Solid Radioactive Waste Management Facility -north fence (east side)
I00H	PLGS Solid Radioactive Waste Management Facility -north fence (centre)
I00I	PLGS Solid Radioactive Waste Management Facility -north fence (west side)
I00J	PLGS Solid Radioactive Waste Management Facility -east fence (north side)
I00K	PLGS Solid Radioactive Waste Management Facility -east fence (centre)
I00L	PLGS Solid Radioactive Waste Management Facility -east fence (south side)

I01	PLGS Solid Radioactive Waste Management Facility
I02	PLGS Dry Fuel Storage Facility
I03	PLGS Dry Fuel Storage Facility -general site area
I03A	PLGS Dry Fuel Storage Facility -south side (next to south corner) / well #4 (shallow)
I03B	PLGS Dry Fuel Storage Facility -south side (next to west corner) / well #4 (deep)
I03C	PLGS Dry Fuel Storage Facility -west corner / well #7 (shallow)
I03D	PLGS Dry Fuel Storage Facility -west side (next to west corner) / well #4 (deep)
I03E	PLGS Dry Fuel Storage Facility -west side (next to north corner) / well #7 (shallow)
I03F	PLGS Dry Fuel Storage Facility -north corner / well #7 (deep)
I03G	PLGS Dry Fuel Storage Facility -north side (next to north corner) / well #6 (shallow)
I03H	PLGS Dry Fuel Storage Facility -north side (next to east corner) / well #6 (deep)
I03I	PLGS Dry Fuel Storage Facility -east corner / well #5 (shallow)
I03J	PLGS Dry Fuel Storage Facility -east side (next to east corner) / well #5 (deep)
I03K	PLGS Dry Fuel Storage Facility -east side (next to south corner) / well #2 (shallow)
I03L	PLGS Dry Fuel Storage Facility -south corner / well #2 (deep)
I03M	PLGS Dry Fuel Storage Facility -well #3 (shallow)
I03N	PLGS Dry Fuel Storage Facility -well #3 (deep)
I11	PLGS -woods between plant & Solid Radioactive Waste Management Facility
I75	PLGS -85 m from stack in the direction of north 73° east (on pole)
I86	PLGS -2nd pole from SRWMF driveway when heading north on main plant road
I87	PLGS -3rd pole from SRWMF driveway when heading north on main plant road
I88	PLGS -4th pole from SRWMF driveway when heading north on main plant road
I89	PLGS -5th pole from SRWMF driveway when heading north on main plant road
I90	at disribution line on west side of dirt road connecting Rte.790 to Duck Cove
I91	100m north of disribution line on west side of dirt road connecting Rte.790 to Duck Cove
I92	200m north of disribution line on west side of dirt road connecting Rte.790 to Duck Cove
I93	300m north of disribution line on west side of dirt road connecting Rte.790 to Duck Cove
I94	400m north of disribution line on west side of dirt road connecting Rte.790 to Duck Cove
I95	500m north of disribution line on west side of dirt road connecting Rte.790 to Duck Cove

I96	on the old Dupont warning sign at the end of the old "dynamite road"
I97	on the west side of the clearing at the end of the old "dynamite road"
I98	PLGS -north of Dry Fuel Storage Facility (200 m north of transmission line)
I99	PLGS -north of Dry Fuel Storage Facility - 100 m north of transmission line
J00	PLGS -180 m from stack in the direction of south (on fence)
J20	PLGS -115 m from stack in the direction of south 19° east (on fence)
J35	PLGS -135 m from stack in the direction of south 34° east (on sign)
J70	PLGS -70 m from stack in the direction of south 69° east (on pole)
K01	PLGS -95 m west of south gate leading to the lighthouse
K02	PLGS Condenser Cooling Water Pumphouse -east fence near surge shaft
K03C	PLGS sewage lagoon (chlorine contact tank)
K03E	PLGS inactive drainage (east lagoon)
K03W	PLGS inactive drainage (west lagoon)
L01	PLGS -old site of cement plant
L02	PLGS -switchyard
L03	PLGS -outer security building (main gate)
L04	PLGS -construction stores
LAB	Fredericton -Health Physics Environmental Laboratory
LEM	PLGS -liquid effluent monitor
M02	PLGS -Administration Building (2nd floor)
MQ	Mactaquac GS
N01	Dipper Harbour -Greg Thompson
N02	Dipper Harbour -Dewey Janes
N03	Dipper Harbour -Ethel Thompson
N04	Dipper Harbour -intertidal zone
N05	Dipper Harbour -beach behind restaurant
N06	Dipper Harbour -offshore
P01	Chance Harbour
P02	Little Dipper Harbour

P03	Liberty Hill
P04	Round Meadow Farm
P05	Chance Harbour -2 km offshore
PLGS	PLGS -general
Q01R	Lorneville
S00	Saint John and surrounding area
SPL	Spruce Lake reservoir
TAYR	Taymouth
X03R	Fredericton -Chestnut Complex lab
X04R	Fredericton -reference seafood
X05R	Fredericton -reference milk test (B. Gay)
X10	Fredericton Junction –Atlantic Dairy Institute

Appendix D
Environmental Reports Of Previous Years

PRE-OPERATIONAL (1976 - 1981)

1 Pre-Operational Environmental Radiation Monitoring Data for Point Lepreau Generating Station. October 1, 1976 to June 30, 1979. NBEPC-HP-79-1. J.A. Flanigan and J.J. Paciga. Sept. 1979.

2 Pre-Operational Environmental Radiation Monitoring Data for Point Lepreau Generating Station. January 1, 1979 to December 31, 1979. NBEPC-HP-80-1. J.A. Flanigan. Sept. 1980.

3 Pre-Operational Environmental Radiation Monitoring Data for Point Lepreau Generating Station. January 1, 1980 to December 31, 1980. NBEPC-HP-81-1. J.K. Sutherland and J.A. Flanigan. July 1981.

4 Pre-Operational Environmental Radiation Monitoring Data for Point Lepreau Generating Station. January 1, 1981 to December 31, 1981. NBEPC-HP-82-1. J.K. Sutherland. February 1982.

OPERATIONAL (1982 - 1996)

5 Operational Environmental Radiation Monitoring Program. Revision 1, January 1982. RD-01364-L15. J.K. Sutherland. Revision 2, June 1983. Revision 3, September 1985. Revision 4, February 1989. Revision 5, August 1993. Revision 6, September **1997.**

6 Environmental Radiation Monitoring Data for Point Lepreau Generating Station. January 01, 1982 (to 1997) to December 31, 1982 (to 1997). HP-07000-83(to 98)-1. J.K. Sutherland. March 1983 (to 1998).

9.0 References

1. Nason, J., *Radiation Protection Directives RD-01364-L2 Rev.3,* Point Lepreau Generating Station Reference Document, 1997.

2. *Solid Radioactive Waste Management Facility 1991Safety Report 87-SR-79100-01,* Point Lepreau Generating Station.

3. Nason, J., *Liquid and Gaseous Effluent Monitoring Program RD-01364-L20 Rev.3,* Point Lepreau Generating Station Reference Document, 1997.

4. Sutherland, J., *Derived Emission Limits for Radionuclides in Gaseous and Liquid Effluents RD-01364-L1*, Point Lepreau Generating Station Reference Document, 1997.

5. Flanigan, J., *Pre-Operational Radiological Environmental Monitoring Program for Point Lepreau Nuclear Generating Station. NBEPC-HP-75-1.* 1975.

6. Sutherland, J., *Operational Environmental Radiation Monitoring Program RD-01364-L15 Rev. 6*, Point Lepreau Generating Station Reference Document, 1997.

7. National Standards of Canada, *Guidelines for Radiological Monitoring of the Environment CAN/CSA-N288.4-M90*, 1990.

8. Bryant, P., *Methods of Estimation of the Dispersion of Windborne Materials and Data to Assist in Their Application.* UKAEA Report AHSB(RP)R42, 1964.

Appendix F
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